Joint ARFTG-RWW 2022 Workshop

Behavioral Modelling, Digital Predistortion (DPD) and Measurement Techniques for High-Frequency Power Devices and Amplifiers

Wednesday Jan. 19, 2022, 8:00-12:00 am

Organizer: Roberto Quaglia, Cardiff University, UK

Co-Organizer: Patrick Roblin, Ohio State University

Abstract:

This workshop consists of a series of talks from prominent international research groups, providing a comprehensive overview of the latest advancements in the measurement, modeling and linearization techniques used for accurate device characterization and conditioning of complex transmitters.

These novel techniques focus on optimizing the resources needed for model extraction and signal conditioning, without compromising the accuracy of the models and correction algorithms, in order to minimize the costs (time, hardware, firmware) and achieve sustainable techniques to support high frequency systems of the next generations.

Speakers:

Sam Kusano, Keysight, USA
Title: Correcting nonlinear distortion of wideband modulated signals using new frequency domain methods.

Anding Zhu, University College Dublin, Ireland
Title: Digital Predistortion of 5G Massive MIMO Wireless Transmitters Using OTA Data Acquisition.

Meenakshi Rawat, IIT Rookee, India
Title: Low complexity predistortion techniques for power amplifiers in multiple input multiple output transmitters.

Pere Gilabert, Polytechnic University of Catalonia, Spain
Title: Digital predistortion for multiple-input, single output power amplifiers

Ehsan Azad, Paul Tasker, Cardiff University, UK
Title: Latest Cardiff model developments

Roman Maršálek, Tomáš Götthans, VUT, Česká republika
Title: Digital and analog predistortion for energy-constrained terminals

Abstracts & Bios

Title: DPD under wideband modulated signal drive using new VNA based methods.

Speaker: Sam Kusano, Keysight, USA

Abstract: This presentation will discuss important aspects of digital predistortion, and present new, state-of-the-art methods to evaluate and extract the quality of test signal generated at power levels where such signal generators are not useful due to their internal distortion. Distortion-less wideband modulated test signals are generated at high power using a new frequency domain method, called spectral digital pre-distortion (Spectral DPD). This technique extends the power range of signal generators, reducing the need for booster power amplifiers to achieve a good linearity, high-power signal for test. Attendees of the workshop will learn about a new technique first creates a short slice of the modulated waveform for fast and accurate linearization of the signal at the reference plane. Then, using a pre-distorted waveform created by spectral DPD, a generic memory-polynomial DPD model is identified. This model is then applied to the original waveform to generate a pre-distorted waveform, providing a linearized test signal. An example 5GNR test signal is demonstrated for linearization. In the workshop presentation, detailed procedure of the spectral DPD and measurement result will be discussed.

Speaker's Bio: Sam Kusano is a scientist for Keysight Technologies' Communication Solution Group. He has over 20 years of experience in measurement applications with RF test equipment such as Vector Network Analyzer, Signal Generator, and Signal Analyzer. Sam started his career in R&D at Agilent Technologies in 2001, designing RF & microwave circuits. In 2020, he has been a scientist in communication solution group in Keysight Technologies, Inc. Sam received master's degree in applied physics at Kyushu University, Japan in 2001.

Title: Digital Predistortion of 5G Massive MIMO Wireless Transmitters Using OTA Data Acquisition

Speaker: Anding Zhu, University College Dublin, Ireland

Abstract: In this presentation, we will discuss digital predistortion (DPD) architectures for massive MIMO wireless transmitters using a real-time single-channel over-the-air (OTA) data acquisition loop. The proposed data acquisition strategy captures OTA signals from a fixed location and indirectly identifies the nonlinear behavior of power amplifiers (PAs) in the array, as well as their combined signals in the far-field direction. The DPD can therefore be effectively constructed without direct measurement at PA output or at user end. The proposed linearization solution can run in real-time and thus does not interfere with data transmission in the MIMO transmitters. It also can achieve robust performance when mutual coupling occurs between antenna elements. A novel low-dimensional feature-based model generation for multi-user MIMO transmitters using OTA data has also been introduced. By identifying the shared properties of different PAs among multiple RF chains, the DPD can be updated quickly and efficiently in response to the dynamic configurations in the transmitter, such as power level or beam angle changes. Simulation and experimental results demonstrate that the proposed DPD approach achieves excellent linearization performance with low complexity, making itself a promising linearization solution for 5G massive MIMO transmitters.

Speaker's Bio: Anding Zhu received the Ph.D. degree in electronic engineering from University College Dublin (UCD), Dublin, Ireland, in 2004. He is currently a Professor with the School of Electrical and Electronic Engineering, UCD. His research interests include high-frequency nonlinear system modeling and device characterization techniques, high-efficiency power amplifier design, wireless transmitter architectures, digital signal processing, and nonlinear system identification algorithms. He has published more than 160 peer-reviewed journal and conference articles. Professor Zhu served as the Secretary of Administrative Committee (AdCom) of IEEE Microwave Theory and Techniques Society (MTT-S) in 2018. He is currently an Elected Member of MTT-S AdCom, the Chair of Electronic Information Committee and the Vice Chair of Publications Committee. He is also the Chair of MTT-S Microwave High-Power Techniques Committee and a Track Editor of IEEE Transactions on Microwave Theory and Techniques.

Title: Low complexity predistortion techniques for power amplifiers in multiple input multiple output transmitters.

Speaker: Meenakshi Rawat, IIT Rookee, India

Abstract: This talk discusses two aspects of predistortion techniques. First talk demonstrates the scheme for extending operating frequency range of a sub-6-GHz range transmiter with the help of frequency quadrupler using two cascaded frequency doubler to millimeter wave (mm-wave). Since the generated harmonics of the frequency doubler is applied to second doubler for mm-wave signal generation, this results in severe distortions and bandwidth expansion of the transmitted signal, which limits the use of such frequency up-conversion method. The signal quality at mmWave level is enhanced using predistortion technique. In addition, this talk describes amalgamation of adaptive dual-input RF predistorter and digital predistorter techniques as a solution to numerical stability problem in digital predistortion for high order MIMO transmitters. It is established with over-the-air-transmission measurement and simulations results that proposed solutions provides a practical low complexity solution for PA nonlinearity in high order MIMO systems.

Speaker's Bio: Meenakshi Rawat (M'09) received M.Sc. and Ph.D. degrees in electrical and computer engineering from the University of Calgary, Calgary, AB, Canada, in 2012. From September 2012 to June 2013, she was a Post-Doctoral Research Fellow with the University of Calgary. From July 2013 to June 2014, she was a Post-Doctoral Project Researcher/Scientist with the Ohio State University. She is currently an Associate Professor with the Indian Institute of Technology (IIT), Roorkee, Uttarakhand, India. Dr. Meenakshi has developed several single-band, multiband, Ultra-wideband solutions to facilitate distortion-free front-end for five different industrial projects, which lead to 3 patents and over 95 IEEE transactions and conferences. She is founding director of the IITR led startup "linearized amplifier technologies and services private limited. She is the coordinator for the Jio 5G laboratory in IITR. She is recipient of Young faculty research fellowship awardee from Digital India Labs.

Title: Digital predistortion for multiple-input, single output power amplifiers

Speaker: Pere Gilabert, Polytechnic University of Catalonia, Spain,
Other co-authors: Wantao Li, David López and Gabriel Montoro

Abstract: Digital predistortion (DPD) can overcome, or at least mitigate, the efficiency versus linearity trade-off in power amplifiers (PAs). Alternative amplification topologies to the linear but power inefficient PAs operating as controlled current sources, have been widely proposed. For example, amplification architectures based on dynamic supply modulation (e.g., envelope tracking) or dynamic load modulation (e.g., Doherty PAs, outphasing PAs or load modulated balanced amplifiers) can boost power efficiency but at the price of presenting worse linear behavior. This talk will focus on the necessary digital baseband signal processing, including but not limited to linearization, to guarantee linearity specifications in high efficient amplification topologies based on dynamic load or dynamic supply strategies that include multiple-input, single output (MISO) power amplifiers. In this context, the necessity of MISO DPD linearizers to compensate for all the unwanted distortion effects that appear at the PA output will be also discussed.

Speaker's Bio: Pere L. Gilabert (Senior Member, IEEE) received the M.Sc. degree in telecommunication engineering and the Ph.D. degree from the Universitat Politècnica de Catalunya (UPC), Barcelona, Spain, in 2002 and 2008, respectively. He developed his master's thesis at the University of Rome "La Sapienza" with an Erasmus Exchange Grant. Dr. Gilabert received the Extraordinary Doctoral Prize for his Ph.D. degree. He joined the Department of Signal Theory and Communications, UPC, in 2003. He is an Associate Professor at the Castelldefels School of Telecommunications and Aerospace Engineering. His research activity is in the field of linearization techniques and digital signal-processing solutions for highly efficient transmitter architectures.

Title: Latest Cardiff model developments
Speaker: Ehsan Azad, Paul Tasker, Cardiff University, UK

Abstract: The generality requirement of advanced RF power amplifier designs, demands load-pull data under various variables such as frequency, input power, and DC bias voltage which can be very time-consuming. Therefore, it is critical to adopt a strategy to reduce the measurement intensity and in doing so, reduce measurement time. One approach to reducing the density of the required load-pull data is to use an accurate and reliable nonlinear behavioral model to interpolate the data. Cardiff University's Cardiff behavioral model is one of the industry-leading nonlinear behavioral models. Its polynomial mathematical formulation was initially developed around a limited operational domain about a large signal operating point, for example at a fixed DC bias level, RF input drive and frequency.To expand the generality of the Cardiff model, variables such as frequency and input drive level have been previously included in the model's formulation. The focus of this workshop is on the recent development of the Cardiff model's formulation to include the DC bias. The new DC-dependent Cardiff model's formulation is capable of accurately interpolate the load-pull data with respect to DC bias; hence, significantly reducing the density of load-pull data over a wide range of DC bias points.

Speaker's Bio: Ehsan M. Azad received the M.Sc. degree in wireless and microwave communication engineering from the Centre for High-Frequency Engineering, Cardiff University, Wales, United Kingdom, in 2019. Ehsan is currently in his third-year Ph.D. research degree under the supervision of Dr Roberto Quaglia, Dr James J. Bell, and Prof. Paul J. Tasker. He has been working on the development of the Cardiff behavioral model, device characterization, and Doherty power amplifier design.

Speaker's Bio: Paul J. Tasker received the B.Sc. degree in physics and electronics and the Ph.D. degree in electronic engineering from Leeds University, Leeds, U.K., in 1979 and 1983, respectively. From 1984 to 1990, he was a Research Associate with Cornell University, Ithaca, NY, USA, where he was involved in the early development of HFET transistors. From 1990 to 1995, he was a Senior Researcher and the Manager with the Fraunhofer Institute for Applied Solid State Physics (IAF), Freiburg, Germany, where he directed the development of millimeter wave GaAs MMICs. In 1995, he joined Cardiff University, Cardiff, U.K., as a Professor, where he established the Centre for High Frequency Engineering, which is now recognized internationally for its pioneering work in developing waveform engineering concepts and their application to microwave and millimeter-wave power amplifier design. He was recently involved in the strategic development of the South Wales Compound Semiconductor (CS) Cluster, the establishment of the Compound Semiconductor Centre (CSC), the CS Catapult, and the EPSRC Future Compound Semiconductor Manufacturing Hub. He is a regular speaker at international conferences and has contributed over 200 journal and conference publications. Dr. Tasker was a recipient of the Honor of Distinguished Microwave Lecturer of the IEEE MTT Society from 2008 to 2010.

Title: Digital and analog predistortion for energy-constrained terminals

Speakers: Roman Maršálek, Tomáš Götthans, Brno University of Technology, Czech Republic

Abstract: As the bandwidths of transmitted signals are continuously increasing, not only the adaptation of digital predistorter (DPD) becomes more computationally complex, but also the power dissipation of the feedback observation receiver represents more and more substantial portion of the overall transmitter energy. A variety of techniques have been proposed recently to reduce the computational burden of DPD adaptation algorithm, including several kinds of sample selection approaches, or methods employing the change of statistics as the signal propagates through the nonlinear device. This talk will provide an overview and practical examples of selected state-of-the-art techniques designed with aim to reduce the complexity of digital predistorter adaptation. Moreover, the digital predistortion will be compared to its continuous-time counterpart – the analog predistortion with digital parameter tuning.

Speaker's Bio: Tomáš Götthans received his Bachelor's degree and his Ing. degree in electrical engineering from Brno University of Technology in 2008 and 2010. In 2011 he joined ESIEE Paris, ESYCOM laboratory where he worked on the project AMBRUN (in collaboration with Thales Communications & Security, TeamCast and Supélec). In January 2014 he received his Ph.D. degree from the Université de Marne-La-Vallée, France. He is currently an Associate Professor at the Department of Radio Electronics, Brno University of Technology. His research interests include digital and analog predistortion of power amplifiers, wireless communications theory, and chaos theory.

Speaker's Bio: Roman Maršálek received his Ing. degree from Brno University of Technology, Brno, Czech Republic, in 1999 and his Ph.D. degree from Université de Marne-La-Vallée, France, in 2003. In 2013, he was a teaching and research fellow at Johannes Kepler University, Linz, Austria. He is currently a Full Professor at the Department of Radio Electronics, Brno University of Technology. His research interests include wireless communications theory and applied digital signal processing for mobile and satellite communications.