WORKSHOPS AND SHORT COURSES

Duration: 09:00 to 13:00  Room 243

WS04

Latest Developments in GaN PA Technologies and Techniques

Organisers
Kamal K. Samanta, Milmega/AMETEK Ltd., UK
Bumman Kim, Pohang University of Science and Technology (POSTECH), Korea

Abstract
Advanced RF/microwave applications demand power amplifiers with ever greater linear power in conjunction with high efficiency and bandwidth at a low cost. As a result, power amplifiers are considered as the most critical and expensive component in a RF-front module, and the new power systems, like RADARs, transmitters, EMC tester, jammers, etc., require the latest state-of-the-art semiconductor and integration technologies to deliver optimum performance within a compact size and light weight. The attractive material properties of GaN make GaN HEMT a superior candidate to meet these demanding requirements, and since its introduction GaN PAs have been creating many records. However, there are much more potential still needs to be better understood and utilized

In a GaN transistor, owing to generation of ultra-high heat flux at the micro-scale gate fingers, PAs are thermally limited much below the electrical capability of the devices. As a result, efficient and novel design technique, thermal management, biasing technique, mode/class of operation etc. play very crucial roles towards gratifying the new generation PA requirements. In addition, withstanding high output mismatch and achieving linearization and modulation requirements with an extreme bandwidth (like in EMC/EW); meeting the power, bandwidth as well as efficiency in Doherty; and the effect of trapping/memory on a device performance raise several technical challenges to address.

This very timely workshop will attribute a wide range of presentations, highlighting the recent important advancements in GaN PA circuits design and linearization to system implementation. Most importantly, the workshop will aware the participants on the critical issues with design hints, technology challenges and the latest state-of-the-art developments in terms of bandwidth, output power, linearity and efficiency, which enabling advanced industrial applications from mono- and multi-band wireless communication to ultra-wideband EMC and RADARs. The speakers are the experts and are the leading contributors in both industrial and academic sectors.

Programme

9:00 - 09:10 Welcome

9:10 - 09:40 Advanced GaN Based Power Amplifier Architectures with Improved Energy Efficiency and Bandwidth Performance
Christian Fager, Microwave Electronics Laboratory, Microtechnology and Nanoscience, Chalmers University of Technology, Sweden
Abstract

9:40 - 10:10 X-band GaN PAs for high PAR communication and radar signals
Zoya Popovic, University of Colorado at Boulder, USA
Abstract

10:10 - 10:40 Advanced Ultra-Wideband GaN Power Amplifier Systems
Kamal K Samanta, Milmega Ltd, Park Road, Ryde, UK
Abstract

10:40 - 11:20 Coffee Break

11:20 - 11:50 Design Approaches for Improved performance of Asymmetric Doherty Power Amplifier
Bumman Kim, Pohang University of Science and Technology (POSTECH), Korea
Abstract

11:50 - 12:20 Broadband, multiband and multiway Doherty PAs with GaN HEMTs
Renato Negra, UMIC Research Centre, RWTH Aachen University, Germany
Abstract

12:20 - 12:50 Advances in Linearization of Wideband GaN Power Amplifiers
Allen Katz, College of New Jersey, USA
Abstract

12:50 - 13:00 Discussion
9:10 - 09:40 Advanced GaN Based Power Amplifier Architectures with Improved Energy Efficiency and Bandwidth Performance
Christian Fager, Microwave Electronics Laboratory, Microtechnology and Nanoscience, Chalmers University of Technology, Sweden

Abstract
This talk will summarize our recent research activities on GaN HEMT based energy efficient, wideband power amplifiers and transmitters. In particular, a generic novel Doherty and outphasing combiner synthesis approach will be presented that enables full utilization of the devices in such configurations. Progress in multi-band and wide-band varactor-based dynamic load modulation transmitters will also be summarized. Linearized modulated measurements will be used to demonstrate the feasibility and performance of the novel concepts presented.

9:40 - 10:10 X-band GaN PAs for high PAR communication and radar signals
Zoya Popovic, University of Colorado at Boulder, USA

Abstract
This talk will overview several X-band PA architectures in the 150-nm GaN on SiC process, all aimed at transmitters for high PAR and high bandwidth signals. Several supply-modulated PAs with dynamic supplies integrated in the same GaN process will be presented with carrier frequencies around 10GHz, 10W peak output power and 60% peak efficiency, accompanied by >85% efficient supply modulators. A Doherty amplifier for radar with amplitude-modulated pulses which enable spectral confinement will be discussed. Outphasing PAs with both isolated and non-isolated combiners with measured internal load modulation and power recycling will be presented. Finally, a harmonically injected PA MMIC which optimizes efficiency and linearity will be proposed as a potential solution for high PAR signal amplification.

10:10 - 10:40 Advanced Ultra-Wideband GaN Power Amplifier Systems
Kamal K Samanta, Milmega Ltd, Park Road, Ryde, UK

Abstract
Many advanced applications, such as EW and EMC, demand ever greater power over an ultra-wide band (multi-octave or decade), within a small size and with high reliability and long life. An amplifier operating in Class-A favors linearity and harmonics, but suffers from lower efficiency and higher thermal load. On the other hand, Class-AB struggles to meet bias stability, gain and linearity needs. In addition, withstand high output mismatch and achieving linearization and modulation requirements with an extreme bandwidth raise several technical challenges to address. These leading to incorporation of precise monitoring control circuits integrated alongside the RF circuits. Moreover, high electromagnetic field enhances inter-circuit coupling which significantly influence the performance of a high power GaN PA.

This presentation will report the new hybrid/module level design and assembling challenges, and advanced developments of ultra-wideband (>decade) very high power GaN PAs and systems, delivering power from tens of Watts to 1 kW (CW). These PAs overcoming limitations of GaN device together with the above constrains, and meeting the stringent requirements. The practical difficulties of assembling would be discussed in details with real-world examples and solutions. In addition, the talk will highlight the die-based hybrid PA design, and assembling techniques used for optimizing the BW, compactness and performance.

11:20 - 11:50 Design Approaches for Improved performance of Asymmetric Doherty Power Amplifier
Bumman Kim, Pohang University of Science and Technology (POSTECH), Korea

Abstract
The Doherty amplifier is consisted of a carrier amplifier and a peaking amplifier. But the two amplifiers function differently. The carrier amplifier should cover the low power region with a high efficiency. Moreover the carrier amplifier should be very efficiency at the first peak power region, where a large portion of the output power is amplified. The peaking amplifier should generate a proper power for the load modulation. For the DPD operation, the peak power of the Doherty PA should be large enough to cover the modulated signal. In view of these different operation characteristics, the two PA should be designed different. We have designed the carrier amplifier for the optimal efficiency at the first peak. For the purpose, the input is matched at the power level and the offset line is also designed at the power level instead of at the peak power level of a conventional design approach. The peaking amplifier is designed to generate more power than the conventional approach. For the purpose, the second harmonic of the input is inductively matched to increase the conduction angle, thereby generate more power. The offset line is tuned for the higher efficiency, while maintains the high impedance level when it is off. The improved performance of the resulting Doherty PA will be introduced.

11:50 - 12:20 Broadband, multiband and multiway Doherty PAs with GaN HEMTs
Renato Negro, UMIC Research Centre, RWTH Aachen University, Germany

Abstract
Doherty power amplifiers is going through a revival since many years now. Inspite of the simplicity of the circuit, this type of PA is so far unrivalled in terms of efficiency and linearity. However, the classical Doherty amplifier is limited in bandwidth. The talk will therefore focus concepts to overcome this limitation: both multiband and wideband Doherty design will be discussed and implementation results shown. Moreover, techniques to extend the back-off efficiency beyond the canonical 6 dB will be also addressed.

12:20 - 12:50 Advances in Linearization of Wideband GaN Power Amplifiers
Allen Katz, College of New Jersey, USA

Abstract
The problem of achieving both linearity and high efficiency in GaN power amplifiers (PAs) over very wide, multi-octave bandwidths requires special techniques not needed for PAs of lesser bandwidth. Both even and odd distortion products must be considered, along with architectures and devices that will allow high efficiency to be maintained over an extended frequency range. This presentation with discuss some of the techniques necessary to achieve very wideband linearization of GaN PAs at microwave frequencies.