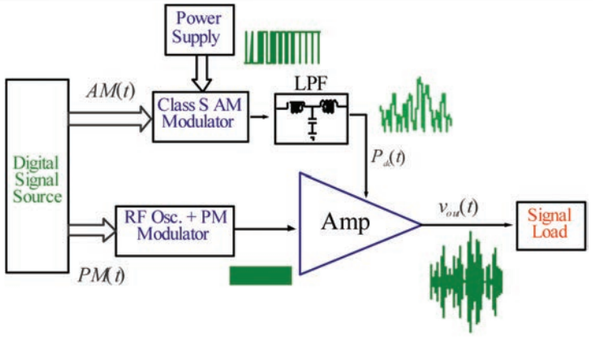
Digital RF Power Amplifiers for Wireless Applications

Digital_PAs is a scientific project that puts together both RF/wireless and power electronics circuit design teams. It is devoted to study the feasibility of incorporating digital techniques and base-band power electronics control circuits in switched-mode wireless power amplifiers and polar transmitters to improve their power efficiency and linearity.



Main Project Team

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Funding Agencies

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Ending Date	01-12-2011

Indicators

Journal Papers	9
Conference Papers	17
Concluded PhD	2
Concluded MSc	9

Two Main Publications

J. Oliveira and J. C. Pedro, **"Efficient RF circuit simulation using an innovative mixed time-frequency method"**, IEEE Transactions on Microwave Theory and Techniques, Volume 59, Issue 4, pp. 827-836, Apr. 2011.

T. R. Cunha, E. G. Lima, and J. C. Pedro, "**Validation and physical interpretation of the power-amplifier Polar Volterra model",** IEEE Trans. on Microwave Theory and Techniques, vol. 58, no. 12, pp. 4012-4021, Dec. 2010.

PROJECT WEBPAGE URL

http://www.it.pt/project_detail_p.asp?ID=1107

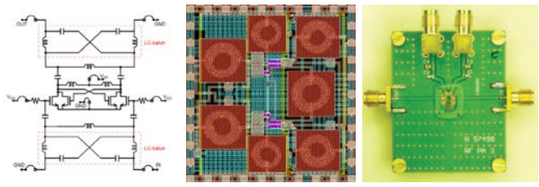

Fig. 1 Pre-processing part of the proposed low-complexity VDLL architecture

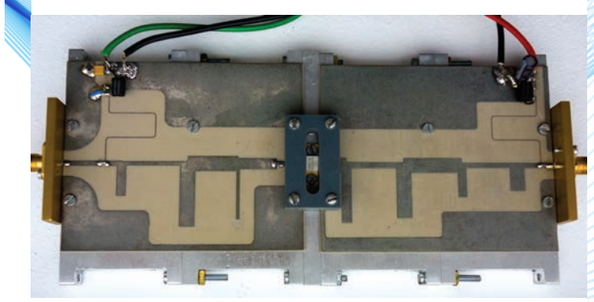

Fig. 2 Circular trajectory estimation with 500 samples, different cell sizes, and BPSK(1) modulation

GENERAL MOTIVATION AND OBJECTIVE OF THE PROJECT

The efficiency of a conventional wireless transmitter (TX) can be optimized through dynamic modulation of the PA bias voltage using switching mode dc-dc. These assume a certain coding of the time-amplitude content, typically as a pulse-width or sigma-delta modulation which has recently led to the introduction of digital techniques in the RF wireless TXs. This opened new fields of research in TX architecture and promises a shift of paradigm on highly linear RF PA design. Digital_PAs aims at investigating the feasibility of incorporating these digital or sampled-data techniques in wireless RF TX designs to overcome the traditional compromise between PAE spectral usage and linearity.

MAIN WORK DESCRIPTION

Digital_PAs addresses both the system architecture and RF circuit implementation levels. In the first case, Digital_PAs is directed to the newly proposed analogue and digital Polar TXs, and compared them to the conventional analog Cartesian or I/Q modulator based architecture. Although various theoretical works have predicted outstanding performances from these architectures, their application into real wireless systems has been limited by the non-idealities of the RF circuitry. That is why Digital-PAs puts together researchers of RF electronics and dc-dc converter technology to address both the system level and implementation aspects in an integrated way.

So, the activities of Digital_PAs can be summarized as follows.

Task-1 investigates the present limiting factors for a more rapid deployment of digital techniques in wireless PAs, from a system's perspective. Using system and system/circuit level nonlinear co-simulation techniques, the addressed digital TX architectures are compared between each other, and with the conventional analogue Cartesian topology. In addition, this Task also proposes new circuit/system RF simulation solutions to efficiently handle the wide disparity of components and signal time scales required by these new wireless TX and digital RF PA designs.

Task-2 studies the practical limits of using digital transmitter technologies in wireless mobile terminal applications. So, it focuses on the design, implementation and test of a RF-CMOS IC medium power amplifier for handset applications.

Task-3 is devoted to study the practical limitations that have impeded the usage of digital TX technologies in wireless infrastructures and to analyse the trade-offs between modulation bandwidth peak to average-power ratio, and nonlinear distortion behaviour of dynamically supplied switching mode PAs. So, it focuses on the design, implementation and test of a GaN HEMT based hybrid PA for the base-station, and studying its associated nonlinear impairments.

Finally, Task-4 is responsible to study the practical limitations faced by high-speed switching mode dc-dc converters when they are used as PAs' dynamic bias modulators.

TECHNICAL ACHIEVEMENTS OF THE IT TEAM

Digital PAs achieved significant technical and scientific results in many areas of electrical engineering proving its cross-disciplinary nature. In particular, it is worth to mention the proposed mixed time-frequency simulation method, in which a clever combination of a frequency-domain harmonic-balance algorithm with a time-step integration engine allowed the efficient simulation of highly heterogeneous circuits, such as the studied digital RF transmitters. Beyond this, a significant system-level modelling work was also developed which proved particularly amenable for predicting the nonlinear distortion impairments of polar transmitters. Finally, many new circuits were designed and tested that covered a wide range of base-band and RF devices such as high-speed dc-dc converter ICs and monolithic and hybrid RF power amplifiers implemented in both Si RF-CMOS and the newly proposed GaN HEMT high-power microwave technology.