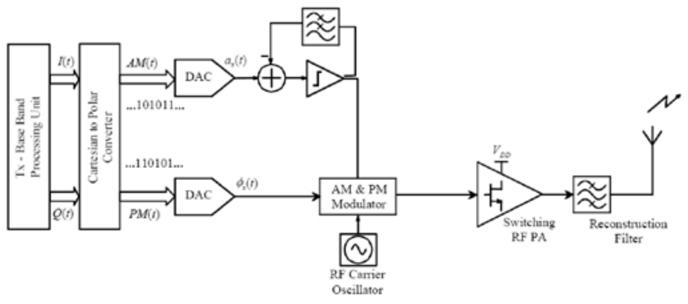
Self-Oscillating Radio Frequency Power Amplifiers

Highly reconfigurable RF transmitters are mostly digital-based up to the RF amplifier. Taking advantage of the switching nature of digital signals, amplifier architectures based on pulse width or pulse density modulation constitute an attractive solution for these transceivers. In this project, self-oscillating power amplifiers are analysed for adequacy to highly reconfigurable transceivers.



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Funding Agencies	
FCT	**64,264 €**
Start Date	01/02/2011
Ending Date	31/05/2013
Indicators	
Journal Papers	9
Conference Papers	10
Concluded PhD Theses	1
Concluded MSc Theses	2

Two Main Publications

P. M. Cabral, L. C. Nunes, T. Ressurreição, J. C. Pedro, **Trapping Behavior of GaN HEMTs and its Implications on Class B PA Bias Point Selection**, Special issue on Linear and Nonlinear Modelling of GaN Transistors and Circuits, International Journal of Numerical Modelling: Electronic Networks, De vices and Fields - accepted and waiting for publication

F. M. Barradas, L. C. Nunes, J. C. Pedro, T. R. Cunha, P. M. Lavrador and P. M. Cabral, **Accurate Linearization with Low Complexity Models using Cascaded Digital Predistortion Systems**, IEEE Microwave Magazine, Vol. 16, Issue 1, pp. 94-103, February, 2015

PROJECT WEBPAGE URL
https://www.it.pt/Projects/Index/1364

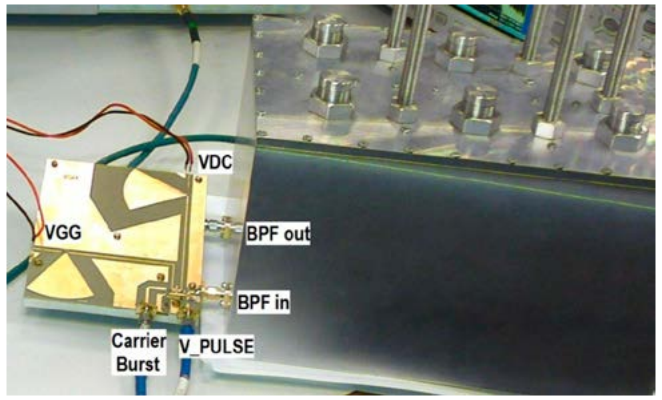

Fig. 1 RF transmitter with cavity filter.

Fig. 2 SOPA prototype.

GENERAL MOTIVATION AND OBJECTIVES

The increase in speed of digital processors is pushing the hardware of RF transceivers closer to the antenna. This leads to more reconfigurable transceivers, ideal for new paradigms as that of Software Defined Radio (SDR). However, switching losses increase with frequency, and so does the complexity of the software-to-hardware interface at the power amplifier stage. In fact, the amplifier can take advantage of the switching nature of the digital interface, implementing techniques based on pulse width or pulse density modulation (as with sigma-delta techniques). In this project, the analysis of novel amplifier architectures that are based on switching oscillation sources are considered, namely those which have built-in in their functional constitution the generation of the oscillating source – the so-called self-oscillating power amplifiers (SOPAs). With the objective of improving the power efficiency, and to evaluate its inherent distortion generation mechanisms (for further compensation), various SOPAs circuits have been analysed, simulated, implemented and tested.

CHALLENGE

The self-oscillating power amplifier has a built-in limit-cycle whose free-running switching oscillation serves as dithering signal, while the amplifier input signal behaves as an injection which the oscillator should follow. In wireless RF transmitters, the high frequency of the carrier leads to practical implementation difficulties. Moreover, the switching amplifier output must then be applied to a highly tuned band-pass filter so that the switching components are removed from the signal to be transmitted by the antenna. The analysis and implementation of these amplifiers is very challenging and difficult, but very important to assess the performance that transmitters achieve with such architectures. In addition, an innovative approach that considers the oscillating loop at the baseband, instead of at the fundamental band, with the aim of significantly reducing switching losses, is proposed and analysed in this project.

WORK DESCRIPTION AND ACHIEVEMENTS

This project was highly successful, enabling the acquisition of important knowledge on self-oscillating power amplifiers, over different lines of work: theoretical operation and behaviour of limit cycle oscillating loops; distortion and linearity analysis of self-oscillating loops; the critical difficulties presented by the interaction between the RF-PA and its output reconstruction filter; the details of hardware implementation of SOPA circuits; and the simulation techniques for the distinct multirate phenomena that SOPA-like circuits present.

Beyond theoretical analysis and simulation, circuit demonstrators were built and tested, namely: SOPA circuits; a highly tuned cavity reconstruction filter; switching amplifiers loaded with the cavity filter. These prototypes not only demonstrated the theoretically derived behaviour characteristics, as were fundamental to verify one of the major results of this project, that the major contribution for efficiency and linearity loss is, in fact, the interaction of the switching PA with the highly tuned reconstruction filter.

A software demonstrator was also developed to successfully show the computation efficiency increase of the novel simulation algorithms that were developed within this project for circuits that involve multirate phenomena such as SOPA circuits.

The consolidated knowledge, which was an outcome of the intensive analysis that the research groups have performed throughout the project, permitted the development of innovative material which was successfully reported on 9 publications in international journals and 10 conference papers.