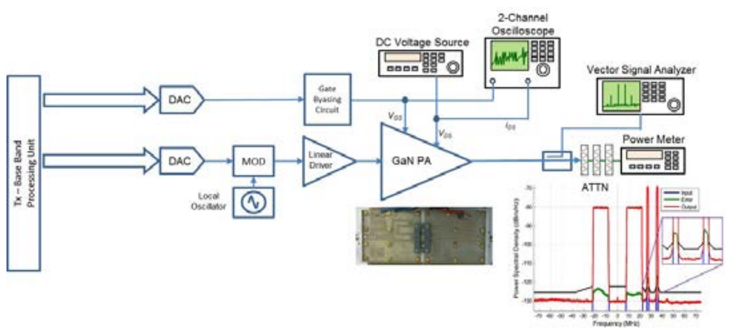
Memory-Effects Compensation in GaN Power Amplifiers

The introduction of state-of-the-art GaN HEMTs in nowadays wireless transmitters was responsible for a big performance improvement in terms of output power, linearity and efficiency. Unfortunately, this technology still suffers from some problems related with trapping effects that are yet to be solved. This project addresses these issues as it builds a memory-free wireless transmitter.



Main Project Team	
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Funding Agencies	
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Indicators	
Journal Papers	4
Conference Papers	3
Concluded PhD Theses	1

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/2051

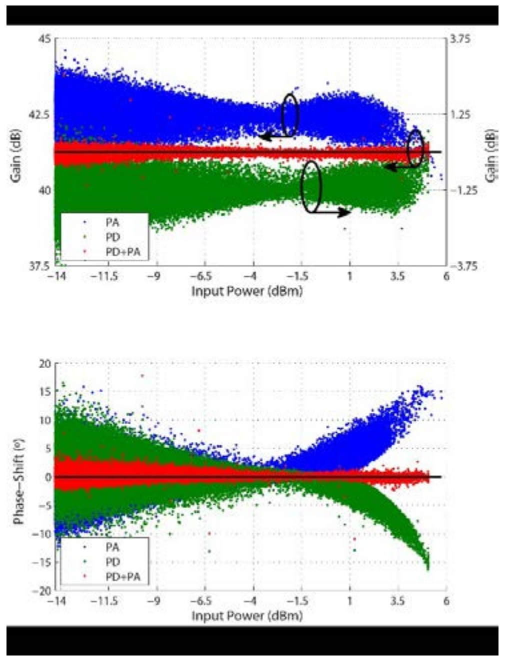

Fig. 1 Final gain and phase-shift characteristics of the original PA, of the linearized PA and of the complete predistorter.

Fig. 2 Photograph of the laboratory measurement setup.

GENERAL MOTIVATION AND OBJECTIVES

Nowadays, it is unquestionable that communication systems play a very important role in our daily routine. Wireless systems, in particular, are growing in such a way that people have difficulty living without the services already available. This being the case, any big change, or improvement, in these systems will have a big impact on what the available resources usage is concerned. This project came exactly in this direction as it tried to push further state-of-the-art systems that, unfortunately, have their own problems inherent to their infancy.

Having that in mind, this project was focused on the design and implementation of a memory-free wireless transmitter built with GaN HEMTs. It is undeniable that this technology was a breakthrough in what PAs efficiency and available power are concerned. Unfortunately, it still suffers from several problems that are yet to be solved. Therefore, the above referred main objective was tackled according to the following different, but interrelated, goals:

(i) Characterize the Memory-Effects arising in GaN HEMT devices;

(ii) Model memory-effects in commercial computer added design simulators.

(iii) Correct the memory-effects (short- and long-term) visible in todays' PAs and prove it with a complete prototype implementation.

CHALLENGE

The technical challenge of this project was to design and implement a memory-free wireless transmitter built with GaN HEMTs which is, without any doubt, the most promising transistor technology in the wireless PAs world.

WORK DESCRIPTION AND ACHIEVEMENTS

The analysis was conducted from both a theoretical and practical points of view, rendering this project an important and updated scientific and engineering value. It was exactly the presented distribution in objectives that was the basis for the project division in the following 3 different tasks:

Task 1: Memory-Effects in GaN Power Amplifiers

There are memory-effects that can be related with the active device itself and other ones that have their origins in the networks that surround the transistor. Thermal and trapping effects are the main responsible for the first group and biasing circuits and matching networks for the second one. Another way of looking into the problem is to group the memory-effects by their specific impact in frequency, resulting in the short- and long-term grouping. The objective of this task was exactly to characterize and separately model these memory-effects. Since biasing circuits (long-term) and matching networks (short-term) are technology independent and, until the appearance of GaN HEMTs, were already present, their characterization and modelling was easier. The distinct characteristic presented by GaN HEMT devices is mainly due to charge trapping effects. So, this task was intended to provide a clear view of what were the main characteristics of these trapping phenomena and find ways of modelling them in a separate way.

Task 2: Digital and Analog Predistorter Design and Implementation

This task was responsible for the evaluation of the digital and analogue predistorters available and decide which type of memory-effects should be allocated to the digital and which should be implemented in the analogue part. This decision satisfied specific criteria such as ease of implementation, capability to accurately correct the desired effect and reconfigurability. After that, the necessary algorithms were implemented for the digital part and the analogue circuits design and implementation was also performed.

Task 3: Compensated GaN Power Amplifier Design and Implementation.

This task was responsible for the design and implementation of the actual complete RF transmitter chain that simultaneously corrected short- and long-term memory-effects.

When it was proposed, this project had, as its main objective, the design and implementation of a memory-free wireless transmitter built with GaN HEMTs. This objective was completely achieved. This statement is backgrounded by the developed theoretical and practical work, from which a significant number of engineering designs, software, laboratory prototypes and publications - not only in international conferences, but also in international journals - resulted.