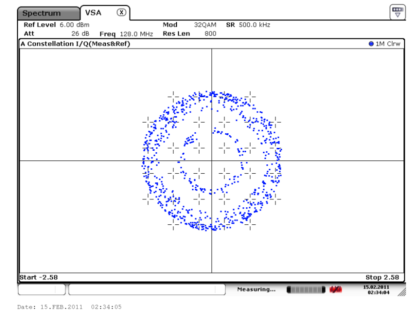
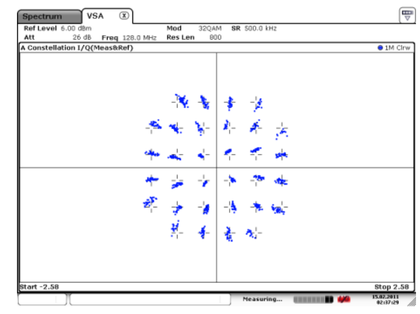
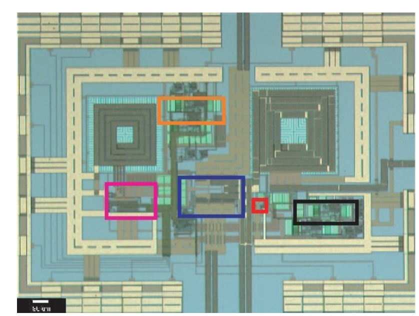
In-Circuit Test and Linearisation of RF Power Amplifiers

Pedro Fonseca da Mota. Defense Dec 2011, supervisor José Machado da Silva

- Complex RF transceivers need to be tested in order to ensure their reliability and functionality.
- Testing time and Automatic Test Equipment price are decisive factors in the cost of the final product. Testing during the product's lifetime is essential to keep its operation within the demanded levels.
- Alternative test strategies and methodologies, such as Built-in Self Test, can be explored to avoid the use of expensive equipment.
- RF Power Amplifiers are one of the major contributors to the non-linear behaviour of transceivers.
- The evaluation of the non-linear behaviour without the need of expensive ATE and performed *in-circuit* recurring to already available units in RF transceivers (DSP e.g.)
- Specified PA output levels need to be satisfied, which requires the presence of automatic gain control when undesirable perturbations are recorded.
- These facilities allow monitoring the device during its lifetime.







Description

This thesis proposes a built in-situ adaptive scheme, which allows adjusting the operation of a RF Power Amplifier (PA), namely, to test it for linearity, to ensure output power regulation and to improve its linearity.

It can be implemented taking advantage of digital signal processing resources and A/D conversion units eventually already available in the system, as well as, of the local oscillator, the mixer, the pre-amplifier (VGA) present in RF transceivers to generate and apply test stimuli.

The evaluation of the RF PA linearity resorts to a polynomial fitting methodology. A LMS algorithm is used to obtain, after gathering the corresponding output responses, the coefficients of the best fitting polynomial and from these, the corresponding compression and third order intermodulation points. The second mode allows regulating the output power in order to ensure constant predefined levels regardless, within reasonable limits, thermal drifts, power supply voltage variations, and behavioural faults occurring in the transmission path. The non-linearity correction mode allows improving the PA linearity to the user defined level after adjusting power supply voltage, VGA gain, and transistor gate bias voltage.

Experimental results were obtained with both single tone and digitally modulated stimuli which confirm the validity and applicability of the proposed test and non-linearity correction scheme. Furthermore, a true power detector was developed, having the obtained experimental results confirmed its correct operation and that load impedance variations can be detected more correctly comparing to the peak voltage sensors.

List of publications

- 15 conference and workshop papers, 3 journal papers (1 published, 2 submitted).
- P.F. Mota, J.A. Machado da Silva, and R.A. Veiga, “Estimation of RF PA Nonlinearities after Cross-Correlating Current and Output Voltage”. Journal of Electronic Testing, 26(1):25-35, 2010.
- P.F. Mota, J.M. da Silva , "A true power detector for RF PA built-in calibration and testing“, *Design, Automation & Test in Europe Conference & Exhibition (DATE), 2011* , vol., no., pp.1-6, 14-18 March 2011.
- P.F. Mota, J.M. da Silva, and J. Long, “An Adaptive Scheme for Estimating and Correcting RF Amplifiers Non-linearities”. In IEEE Asia Pacific Conference on Circuits and Systems, APCCAS 2008.
- Pedro F. Mota, J. Machado da Silva, “Estimation of Linearity Characterization Parameters on RF PA’s with Strong Nonlinearities” in XXII Conference on Design of Circuits and Integrated Systems , November 2007, Seville.
- Pedro F. Mota, J. Machado da Silva, “An Adaptive Scheme for Estimating and Correcting RF Amplifiers’ Non-Linearities, submitted to IEEE Transactions on Circuits and Systems, Dec 2011.
- Pedro F. Mota, J. Machado da Silva, “Evaluation of RF PA Non-Linearities After Cross-correlating Current and Output Voltage, submitted to Microelectronics Journal, Elsevier, Jan 2011.