Generalized Linear Amplification With Non-linear Components for Power and Spectral Efficient Broadband Wireless Systems

Every new generation of wireless systems envisions improving power and spectral efficiencies while transmitting over severely dispersive channels. A huge power loss results from the necessity of employing linear amplifiers at the front-end of mobile handsets. The development of signal processing and modulation techniques enabling high efficient amplification is thus of great interest.

Main Project Team	
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Indicators	
Funding	12k €
Journal papers	4
Conference papers	19
Patents	3 (1 pending)
Concluded MSc	3

Two Main Publications

M. Gomes, V. Silva, R. Dinis, P. Carvalho, P. Bento, PATENT OF A TRANSMISSION METHOD WITH DOUBLE DIRECTIVITY, PP 108149, January, 2015.

M. Gomes, V. Silva, R. Dinis, P. Carvalho, A. S. Simões, TRANSMISSOR LINC COM EFICIÊNCIA MELHORADA PARA SINAIS DE BANDA LIMITADA, PP 107875, September, 2014

PROJECT WEBPAGE URL

https://www.it.pt/Projects/Index/1939

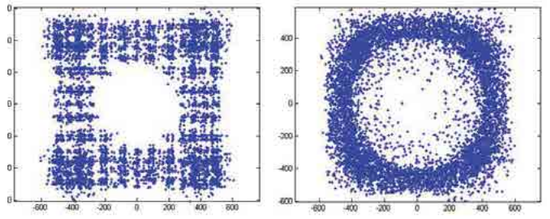

Fig. 1 IQ transition Diagram of bandwith Limited OQPSK signal with and without the use of RMM technique, obtained with the SDR implementation prototype.

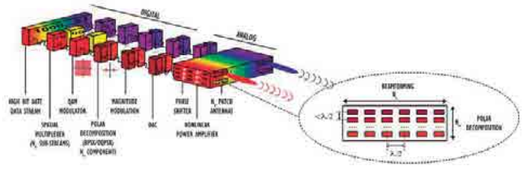

Fig. 2 Generic block diagram of mm-Wave transmitter with high power and spectral efficiency (PT 107875 (A))

GENERAL MOTIVATION AND OBJECTIVES

Broadband wireless systems require high power and spectral efficiencies, while transmitting over severely dispersive channels. Developing on the concept of Linear Amplification with Non- Linear Components (LINC), the main technical objective of the project was to design, implement and validate a new set of digital transmission techniques with high power and spectral efficiency for future wireless broadband systems, to be employed in the uplink of mobile systems or in satellite communications. The main goal was to design signals with low Peak-to-Average Power Ratio (PAPR) or even quasi-constant envelope and high spectral efficiency, employing amplification techniques based on low- cost, highly efficient grossly NonLinear (NL) amplifiers (e.g., class D and E amplifiers), which are simpler and have higher amplification and output power than quasi-linear amplifiers. Since a grossly NL amplifier is only suitable for signals with quasi-constant envelope, the project aimed to develop new signal designs and/or transmission techniques compatible with grossly NL amplifiers. This research project has combined theoretical development (including signal and receiver design), CMOS implementation of key components (with emphasis on matched amplifiers and output power combination with minimum losses) and FPGA-based implementation for an overall system's proof of concept, for the most promising techniques.

CHALLENGE

Development of signal processing and new modulation techniques for improving the power and spectral efficiency of systems, by allowing the use of high efficiency nonlinear amplifiers at transmitters front-end.

WORK DESCRIPTION AND ACHIEVEMENTS

Although with initial emphasis on Single-carrier (SC) transmission, GLANCES project addressed both SC and Multi-Carrier (MC) systems, with important contributions on both domains for the next generation of wireless systems, namely in context of 5G and millimetre wave communications.

Regarding SC systems, usually employed at uplink due to the much lower PAPR of SC's signals, new signal processing techniques were developed under GLANCES, allowing the decomposition of traditional SC constellations as a sum of bandlimited OQPSK signals with low-envelope targeted to be transmitted through different antennas. The optimization of the OQPSK components, was also addressed with the proposal of a new Ring-type Magnitude Modulation technique (RMM) allowing to generate OQPSK signals with bandwidth close to the minimum Nyquist band and almost no envelope fluctuation; this allows the employment of linear amplification with non-linear components (LINC) with considerable power efficiency gains and minimum non-linear amplification distortion due to the use of saturated non-linear amplifiers. A demonstrator of RMM techniques applied to OQPSK signals has been developed on a Software Defined Radio (SDR) platform. As major outcomes, this work gave rise two 3 patents (PT 107874, PT 107875 (A), PT 108149 (A)/USPT 14995348).

GLANCES project also launch the basis of a new class of OFDM-type signals, regarding the efficient amplification of MC signals employing cyclic prefix based OFDM techniques. A new block-windowed OFDM (BW-OFDM) transceiver has been proposed allowing for considerable power efficiency gains when compared to conventional OFDM systems, while granting similar bit error rate performance and computational complexity. The development of BW-OFDM techniques, whose basis was launched within GLANCES project are ongoing, namely in the context of multi-input multiple-output (MIMO) systems.