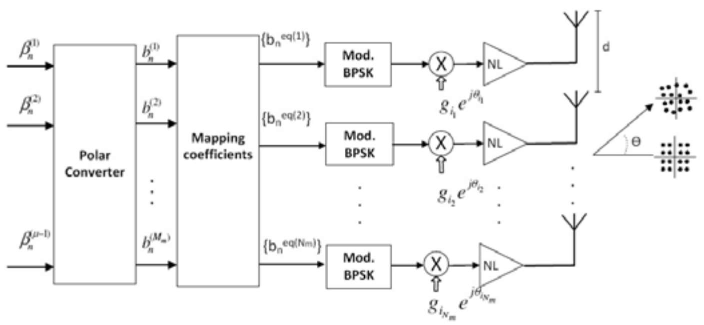
GALNC

Generalised Linear Amplification with Nonlinear Components for Broadband Wireless Systems

Design of OQPSK-type signals with quasi-constant envelope and good spectral characteristics;-Design of MM schemes to be combined with LINC-type techniques;-Design of linear amplification schemes for general constellations that employ multiple NL amplifiers;-FDE design of MM and OQPSK-type schemes;-Definition of matching requirements for multi-amplifier techniques.



Main Project Team	
Paulo Montezuma	**RS-Lx**
Rui Dinis	RS-Lx
Marco Gomes	MSP-Co
Vitor Silva	MSP-Co
Mario Marques da Silva	RS-Lx
Funding Agencies	
Fundação para a Ciência e a Tecnologia, PTDC	**153,000€**
Start Date	01-2010
Ending Date	12-2012
Indicators	
Journal Papers	5
Conference Papers	20
Patents	4
Concluded PhD Theses	1
Concluded MSc Theses	5

Two Main Publications

J. F. T. Teles, P. Bento, M. Gomes, R. Dinis, V. Silva, **Block-windowed burst OFDM: A high-efficiency multicarrier technique**, Measurement, Vol. 50, No. 23, pp. 1757 - 1759, November, 2014

J. Guerreiro, R. Dinis, P. Montezuma, **Use of Equivalent Nonlinearities for Studying Quantization Effects on Sampled Multicarrier Signals**, Measurement, Vol. 52, No. 2, pp. 151 - 153, January, 2015

PROJECT WEBPAGE URL
http://tele1.dee.fct.unl.pt/galnc

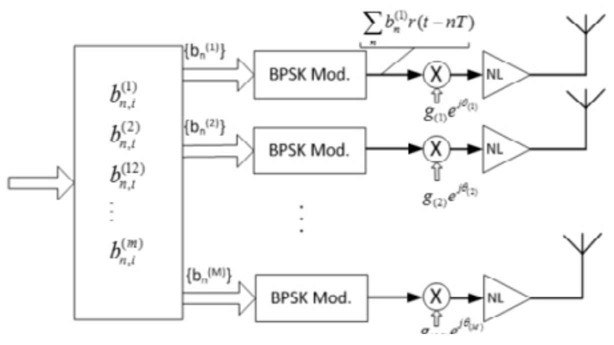


Fig. 1 Transmitter structure.

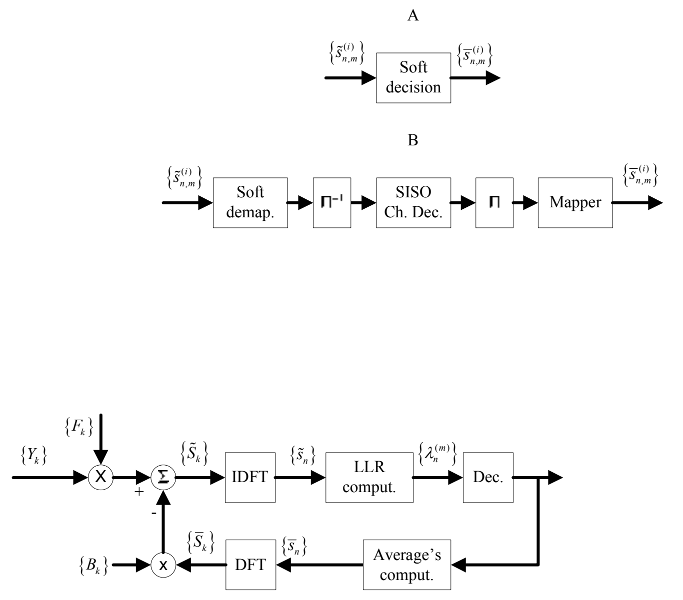


Fig. 2 Receiver structure with detail of the decision block in the uncoded (A) and coded (B) cases.

GENERAL MOTIVATION AND OBJECTIVES

This project addressed the design, implementation and validation of digital transmission techniques with high power and spectral efficiency for future wireless broadband systems, with focus on transmission techniques compatible with highly efficient grossly NL (Non-Linear) power amplifiers. For that purpose new signal designs and/or transmission techniques compatible with grossly NL amplifiers were developed.

CHALLENGE

Design and implementation of digital transmission techniques with high power and spectral efficiency to be employed in the uplink of mobile systems or in satellite communications.. Design signals with low PAPR (Peak-to-Average Power Ratio) or even quasi-constant envelope and high spectral efficiency and employ amplification techniques based on low-cost, highly efficient NL (NonLinear) amplifiers (e.g., class D and E amplifiers), which are simpler and have higher amplification and output power than quasi-linear amplifiers .

WORK DESCRIPTION AND ACHIEVEMENTS

The research followed two different approaches: in the first one the transmission chain used band-limited signals based on different constellations (e.g., QAM, PSK or dense constellations such as Voronoi constellations) combined with LINC (Linear amplification with Nonlinear Components). MM (Magnitude Modulation) techniques were employed to improve LINC efficiency and control oversampling requirements, and it was given focus on the design MM for different pulse shaping (not necessarily Nyquist) with good PAPR characteristics.

The second approach relied on the decomposition of a given multilevel constellation (QAM, PSK, Voronoi or any other constellation) as the sum of several binary components. Each of these binary components is submitted to a separate OQPSK (Offset Quadrature Phase Shift Keying) modulator. The signal associated to each OQPSK modulator is designed to have quasi-constant envelope so it can be amplified without distortion by grossly NL amplifiers. The outputs of the different NL amplifiers are then combined for form an amplified version of the original signal (without distortion). To achieve an overall system's spectral efficiency comparable with the minimum spectral efficiency of a given multilevel constellation (i.e., with minimum Nyquist bandwidth), it was considered an FDMA (Frequency Division Multiple Access) approach using OQPSK-type frequency channels that are separated by the minimum Nyquist bandwidth.

SC-FDE (Single-Carrier with Frequency-Domain Equalization) schemes were adopted, because SC signals can be designed to have relatively low PAPR (Peak-to-Average Power Ratio) and its frequency-domain receiver implementation makes them appropriate to severely time-dispersive channels. For improved detection efficiency, several IB-DFE (Iterative Block Decision Feedback Equalizer) were designed with several DFE implementations with different complexity/performance tradeoffs (e.g., considering only the most relevant component of each OQPSK-type signal or trying to detect all components).

For both approaches perfect gain and phase matching between the different NL amplifiers are needed. However, in practice there are unbalances between amplifiers and their impact on performance of both approaches were characterized.

Key contributions developed in this project include:

- the development of improved transmission systems usable with non-linear amplifiers and security at physical layer;
- the development of a Ring-type Magnitude Modulation (RMM) technique tuned to optimize LINC combiner's efficiency;
- the development of new transmitter structures suitable for Massive MIMO systems;
- the development of a amplifier layout and respective simulation;
- the definition of practical specifications for the amplifiers needed in a transmitter structure based on the second approach, having in mind a further practical implementation of a hardware demonstrator.
- 4 patents.