Cognitive Radios Adaptable Wireless Transceivers

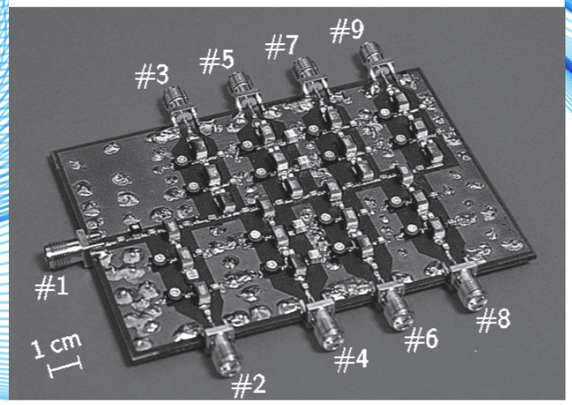


Fig. 1 RF cochlea implementation.

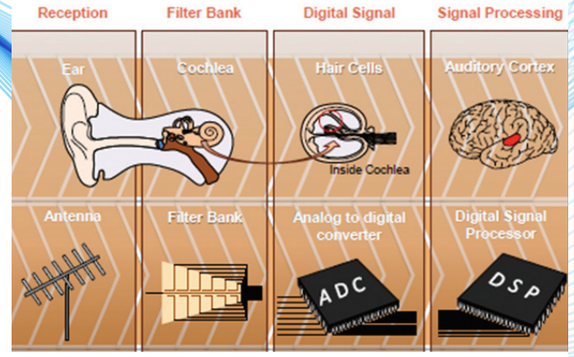
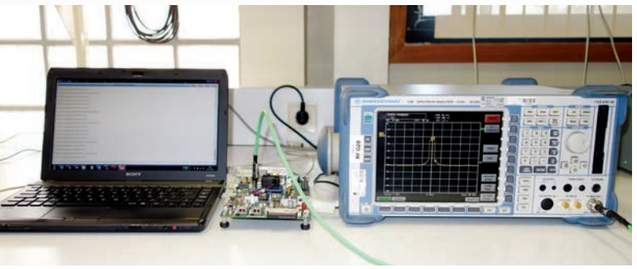


Fig. 2 Laboratorial setup.

Sdr has already started its way to conquer traditional radio configurations, by moving base band (de)modulators completely to the digital world, implementing them in software or re-configurable hardware. This project aimed to study some of the current sdr physical layer limitations, starting from agile rf front ends and considering fpga based implementations with improved flexibility, efficiency and dynamic range figures of merit.



Main Project Team

Nuno Borges de Carvalho	**Nm Av**
José Neto Vieira	Nm Av
Arnaldo S. R. Oliveira	Nm Av
Pedro Cruz	Nm Av
Nelson Silva	Nm Av
Daniel Albuquerque	Nm Av

Funding Agencies

Fundação para a Ciência e a Tecnologia Ptdc/Eea-Tel/099646/2008	153.510€
Start Date	01-01-2010
Ending Date	01-12-2012

Indicators

Journal Papers	6
Books	2
Conference Papers	28
Concluded PhD Theses	1
Concluded MSc Theses	8

Two Main Publications

Cruz, P.M.; Carvalho, N.B.C.; **"Wideband Behavioral Model For Nonlinear Operation Of Bandpass Sampling Receivers",** Ieee Trans. On Microwave Theory And Tech., Vol. 59, No. 4, Pp. 1006 - 1015, April, 2011.

Silva, n.V.S.; Oliveira, a.O.; Carvalho, n.B.C.; **"Design and optimization of flexible and coding efficient all-digital rf transmitters"**, ieee trans. On microwave theory and tech., Vol. 61, No. 1, Pp. 625 - 632, January, 2013.

PROJECT WEBPAGE URL

http://www.it.pt/project_detail_p.asp?id=1264
http://ipis.av.it.pt/taccs/

GENERAL MOTIVATION AND OBJECTIVE OF THE PROJECT

Nowadays, new telecommunications standards or new releases of existing ones (e.G., Worldwide interoperability for microwave access (wimax), 3gpp long term evolution (lte), universal mobile telecommunications system (umts), high speed downlink packet access (hsdpa), etc.) Are constantly appearing. In this scenario, interoperability across existing standards is a crucial requirement to achieve a high quality of service (qos). Software defined radio (sdr) technology holds the best promise of meeting this requirement whilst efficiently tackling the ever-increasing complexity of radio systems.

One of the most interesting potential applications of sdr is to increase the spectrum occupancy by designing opportunistic radio systems, i.E. Systems capable of dynamically allocating regions of the spectrum that happen to be free at a given moment, which implies the ability to "see" or "be aware" of the entire spectrum and its usage at a precise time. This has motivated the scientific community to study different radio architectures with the ability of detecting signals over a broad frequency band with a high dynamic range. This requirement poses problems due not only to bandwidth restrictions but also to high peak-to-average power ratio (papr) demands or rf interference from one or more sources.

CHALLENGE,

Building flexible multi-mode/multi-standard sdr and cognitive radios (cr) requires digital processing of high-frequency and wide-band signals, which is challenging in terms of sampling rate, operating speed, dynamic range and power consumption.

In that respect several objectives were proposed:

In this project the main objective was the study and design of transceiver architectures for cognitive radio applications.

In order to achieve the project was divided into several sub-objectives:

1 – Study and evaluate the signal statistics, and signal behaviour of the expected waveforms to be used in cr approaches

Improved algorithm for signal quality evaluation, and also signal processing approaches for reducing peak to average power ratios and maximize the dynamic range of the hardware components was achieved.

2 – Proposal of new and improved behavioural models for hardware components

Several models able to characterize low noise amplifiers, power amplifiers, adaptable filters, mixers and digital to analog, and analog to digital converters. These models were optimized for the nonlinear and dynamic operation of the adaptable rf front end.

3 – Propose very wide bandwidth receivers for spectral sensing

The sub-system responsible for spectral sensing is expected to be very wideband. New architecture for very wideband receivers were proposed, those allowed the correct identification of the spectrum and the associated communication scenario. It is expected to combine improved hardware solutions with robust signal processing tools to achieve spectral reconstruction.

4 – Propose new algorithms for spectral sensing

Robust spectral processing approaches for spectral sensing and signal information and discover signal information that goes beyond the pure spectral occupancy, and power spectral density evaluation were proposed and tested successfully.

5 – New algorithms to be able to reconfigure fpga's on the fly based on the decisions gathered and proposed by the dsp algorithms, the fpga approach should adapt in an almost real time solution.

New and improved architectures and algorithms to re-configure the fpga's based on these new dsp outcomes were proposed and tested successfully.

6 – With the knowledge gathered with the previous work, a new and agile radio front end will be built

A new radio approach, for the receiver of the spectral sensing subsystem, and also for the

Receiver and transmitter of the communication path cr sub-system was built and tested.

TECHNICAL ACHIEVEMENT OF THE IT TEAM

1 – Study and evaluation of the signal statistics, and signal behaviour of the expected waveforms to be used in cr approaches

2 – Proposal of new and improved behavioural models for hardware components

3 – Proposal of very wide bandwidth receivers for spectral sensing

4 – Proposal of new algorithms and receivers for spectral sensing

5 – Very high dynamic range receivers were proposed

6 – New algorithms able to reconfigure fpga's on the fly were proposed.

7 – All digital transmitters based on fpga design was achieved, including the first multi-band all digital transmitter.

8 – With the knowledge gathered with the previous work, a new and agile radio front end was built