Validation Of An Open Source Software Defined Radio Test Bed

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***Abstract*—This paper presents a low-cost measurement method for MIMO antenna performance assessment based on the open-source OpenAirInterface initiative. MISO 8x1 measurements are presented to experimentally prove the reproductibility of the test method, using a prototype with 8 antennas at 2.6 GHz integrated into a 140x140x40mm femto cell. The results shows that measurements are repeatable with a good accuracy. Beamforming performance are presented to finalize the validation of the setup.**

I. Introduction

In the last few years the wireless communication witnessed the emergence of new technologies subsequent to the exponential increase of the mobile traffic data [1]. Multiple Input Multiple Output (MIMO) techniques have been established as one of the spearhead of this new technologies, enhancing spectral efficiency and increasing channel capacity. The latest LTE release targets up to 8x8 MIMO schemes as well as the 802.11ac WLAN standard. Multi-antennas techniques such as beamforming, spatial multiplexing and diversity, aim to take advantage of channel characteristics to increase data rates or reliability [2] through SNR improvement.

Characterizing MIMO systems is challenging for antenna designers because the global communication system along with channel characteristics need to be taken into account in a multi-path environment. Indeed considering the radiating element alone is not enough to assess MIMO performance, so classical measurements in anechoic chamber are not sufficient. Over The Air (OTA) solutions [3] have been proposed to perform measurements at the system level including modulation code schemes (MCS) and 3GPPP standards. However the industrial OTA test beds to assess MIMO performance rely on radio channel emulators which are expensive equipment proposed only by few suppliers (e.g., Agilent, Rhodes&Schwarz, Satimo, Anite) and are still under development for Massive MIMO techniques [4].

In this paper, we present the design of a low cost OTA measurement system using existing Software Defined Radio (SDR) boards to assess the performance of multi-antenna access points. The main idea is to leverage the OpenAirInterface (OAI) platform developed by EURECOM [5], interfaced with ExpressMIMO2 PCI Express (PCIe) boards. The effectiveness of the system is confirmed by the reproductibility of the measurements, which have been obtained using a plastronic gateway with eight antennas.

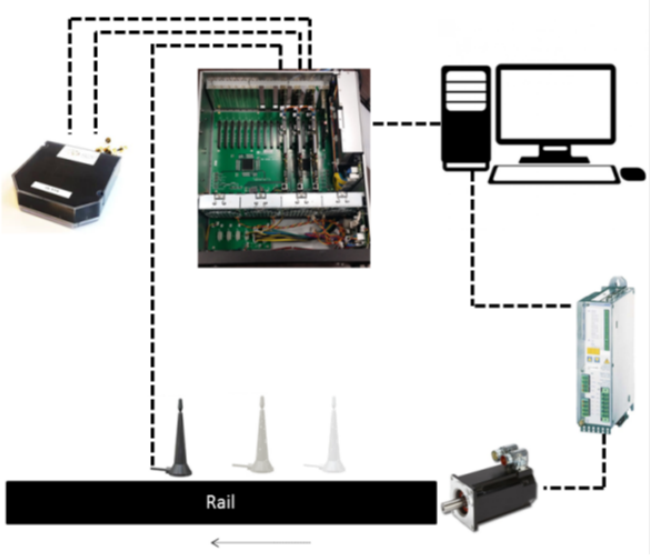

Fig. 1. Schema of the Measurement Setup

II. Test Bed Overview

Wireless systems constituted with a large number of antennas must be characterized in a multipath channel environment. Indeed free space radiation measurements and S-parameters are not sufficient to assess beamforming or MIMO performance. Real conditions test can be realized thanks to the OAI platform.

A. Measurement Setup

Fig. 1 presents the architecture of the system. It consists of three ExpressMIMO2 boards, two are acting as Evolved Node B (eNB) and one as User Equipement (UE), running on common x86 Linux machines. Each motherboard features 4 parallel RF chains with bandwidths up to 20 MHz (4x5 MHz, 2x10 MHz, 1x20 MHz) per chain covering the range of $350 - 3800$ MHz. It interconnects with a baseband computing engine using Gen1 1-way PCIexpress. The latest version of the ExpressMIMO2 board has also built-in amplifiers, LNAs, and switches for FDD and TDD operations. The UE is

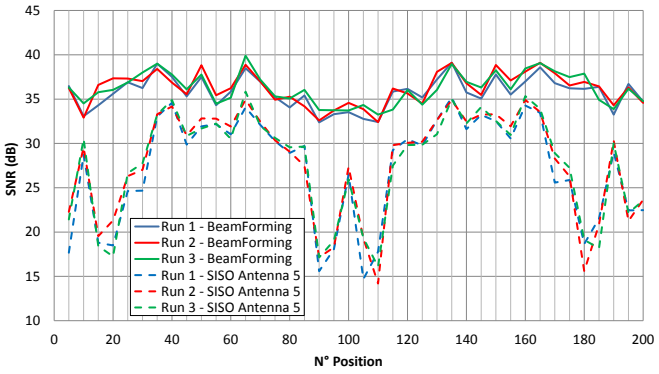

Fig. 2. Dispersion among 3 identical MISO 8x1 and SISO SNR measurements

embedded on an automated 4 meters long rail to perform statistic measurements in different propagation channels. The eNB is in a static position at 4 meters from the center of the rail. The measurement setup aims to characterize various antenna configurations for MIMO application.

B. System Configuration

The proposed setup is configured to operate in Time Division Duplexing (TDD) mode in a 8x1 MISO communication at 2.68 GHz. The eNB is connected to eight antennas integrated in a 140x140x40 mm plastronic gateway designed with Laser Direct Structuring (LDS) technology. The topology of those antennas and their characteristics have been presented in [6]. The UE uses a monopole reference antenna embedded on the rail. Measurements are performed in a line of sight configuration. The eNB transmits 10 LTE OFDM frames with a 5 MHz bandwidth and a transmitted power of 10 dBm. The power is chosen to insure a good level of reception in the whole room while avoiding saturation of receiving RF chains.

III. Measurement Results

In order to determine reproducibility of the test method we repeated three times the same test case. These latter consists of measuring SNR values for 200 positions with a 3 cm step on the rail. The rail is going forward for the first 100 positions and backward for the last 100. At each position we retrieve the SNR for the eight antennas in a SISO configuration as well as the SNR in a MISO 8x1 configuration. For a matter of readability Fig. 2 presents the beamforming results (MISO 8x1) along with one antenna measurement (SISO antenna n. 5) for only 40 out of the 200 positions. We observe that whatever the case, there is a very low dispersion among the measurements. The symmetrical pattern of the curve is explained by the two-way movement on the rail.

Tab. 1 details the average dispersion calculated over the 200 positions and the three runs. The overall average dispersion is +/- 1.3 dB. The accuracy is satisfying compared to the level of the measured SNR. This accuracy might be improved by adding filters to the system.

TABLE I
AVERAGE DISPERSION FOR 8 ANTENNA AND MISO BEAMFORMING

Antenna Configuration	Average Dispersion (dB)
SISO - Antenna 1	+/- 1,6
SISO - Antenna 2	+/- 1,6
SISO - Antenna 3	+/- 1,3
SISO - Antenna 4	+/- 1,3
SISO - Antenna 5	+/- 1,1
SISO - Antenna 6	+/- 1,5
SISO - Antenna 7	+/- 1,3
SISO - Antenna 8	+/- 1,2
MISO 8x1 Beamforming	+/- 0,67

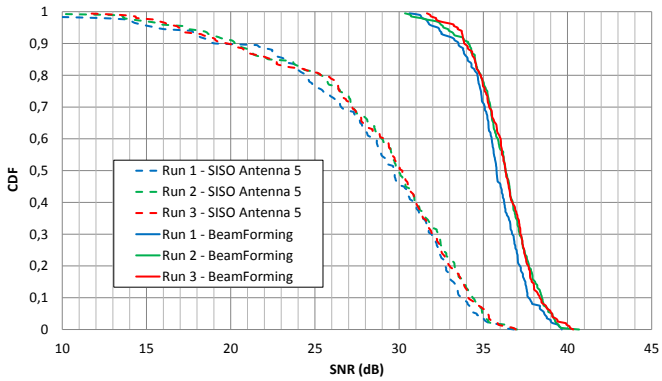

Fig. 3. Beamforming Gain between SISO and MISO 8x1

Finally, Fig. 3 presents the Cumulative Distributed Function (CDF) for the full 200 measurements. We observe that beamforming gain is the same for the three run.

IV. Conclusion

In this paper we presented the experimental validation of a new low cost measurement method for MIMO performance assessment. The results show a good accuracy of the measurement setup and validate the reproducibility of the method. A comparison using various antenna prototypes will be presented at the conference.

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