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Test Setup for Anechoic Room based MIMO OTA Testing of LTE Terminals

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***Abstract*—Over-The-Air (OTA) performance testing is becoming a key method for Multiple-Input-Multiple-Output (MIMO) enabled devices as it allows evaluation of most aspects of the radio communication performance. This topic has become a very important research topic especially because such technology is now introduced into, for example, LTE and WiMAX systems. The main purpose of this testing is to validate that the user equipment will have a good performance in real use. CTIA, 3GPP and COST are spending a big effort in standardizing the OTA testing procedure which is much more complex than similar SISO OTA testing. The CTIA MIMO OTA SubGorup (MOSG) is comparing each proposed MIMO OTA technique to establish, first, an exact methodology for each technique and second, to ensure each of them offers equivalent results. This contribution focuses on the multi-probe anechoic chamber solution and summarizes the activities related to the MIMO OTA lab being built at Aalborg University (AAU), Denmark and the testing being performed.**

***Index Terms*—MIMO OTA, CTIA, performance evaluation, multi-probe setup**

I. Introduction

The fast roll out of Long Term Evolution (LTE) networks and its mandatory MIMO enabled devices have created a demand for an OTA measurement methodology for characterization of the LTE user equipment (UE). This question has been addressed to 3GPP [1], CTIA and COST, where after two rounds of measurement campaigns didn't provide conclusive results on which of the proposed methodologies should be used [2], [3]. Currently, a new round robin is being performed by CTIA MOSG with the experience built from previous attempts [4] whose point is to reach an exact method to reproduce the same characteristics for each technique. A high level of reproducibility is mandatory and while testing the maximum amount of possibilities, the test methodology must be kept simple.

II. Measurement setup

Figure 1 shows a simplified version of the multi-probe setup mounted at AAU for testing a device under test (DUT) which is placed on a pedestal in an anechoic chamber surrounded by 16 probes mounted on a 4 meters diameter ring. The probes are designed by AAU [7] and currently not all antennas can be connected simultaneously with both polarizations due to the limited number of fading channels in the channel emulators. The number of probes makes the setup suitable to test any of the currently available LTE phones and most of the LTE tablets at the standardized LTE bands [5], [6].

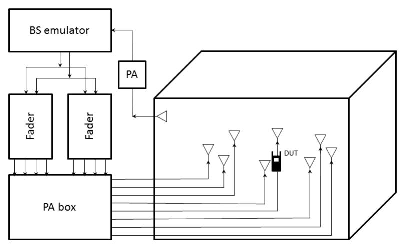

Fig. 1: Basic scheme of multi-probe test technique used for testing DUT with a BS emulator

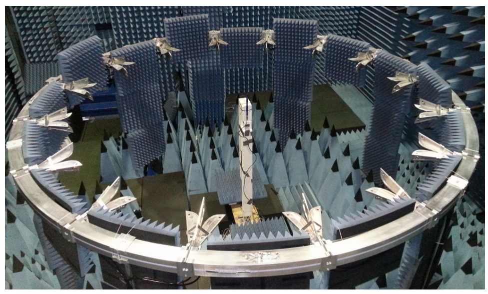

Fig. 2: Aluminium ring with OTA probes covered by absorbers to avoid non-desired interactions

As shown in Figure 2, the ring is covered by absorbers to avoid interactions with the emulated field. The probes are connected to a channel emulator (2 EB F8 Units) through Power Amplifiers (PA). A base station (BS) emulator, R&S CMW 500 and a Vector Network Analyzer (VNA) are connected via a switching unit to the faders. For LTE signaling purposes, a monopole antenna is located at the base of the pedestal and connected through a PA to the uplink port of the BS emulator. The PAs are inserted in the system so that the dynamic range is suitable for terminal testing. The pedestal, made of polystyrene, is provided with a rotation axis on the center and a linear motion system. These features can be used to rotate the DUTs over the azimuth plane.

A software framework has been developed around each of the elements on the setup to automate all the functionalities from the system. This setup is intended for several purposes but only LTE terminal testing is addressed on this document.

The system requires calibration [10], more details about the calibration procedure and its consequences will be shown in the full paper

III. Measurement Campaign Description

This document addresses two test campaigns being performed at AAU which are related on topic but differentiated on purpose. Those are the CTIA MOSG round robin campaign [4] and Live LTE terminal test campaign.

A. Inter-Lab Inter-Technique OTA Performance Comparison Testing for MIMO Devices

Its main goal is to establish a fair comparison between OTA techniques, while tracking the ability of each methodology to reproduce the key characteristics of each channel profile [4]. Using Absolute Throughput as the figure of merit (FoM) [8], the testing uses a fixed Modulation and Coding Scheme (MCS) and sweeps over Signal-to-Noise Ratio (SNR) calculated at the receiver (RX) antenna ports and, optionally, over different azimuth orientations. In order to control the effect of the antennas, the CTIA reference antennas are used while keeping the DUT inside a metal box to diminish its interaction with the environment [9].

B. Live LTE terminal test campaign

The goal is to be able to find a fair way to rank different LTE devices, based on their ability to perform under different conditions. This effort will include realistic channel models and also standardized profiles. Overall, it is intended to isolate and quantify the effect of the following characteristics:

- Channel profile
- DUT orientation and position with respect to the channel
- DUT antennas. CTIA reference antennas will be used.

Throughput will also be used as FoM, although in its format of link adaptation curves (LA) using 10 of the 28 available MCS. For time variant channels, the number of blocks needed to get a converged BLER depends on the Doppler associated channel and also on the modulation scheme used. Note that testing time also increases with the number of blocks used. In the end a variant number of block depending on the MCS will be used. Other settings not specified here are set as in [4].

IV. Results

Some examples to be shown in the full paper are presented here.

As a first approach, from all 16 dual polarized probes on the ring only 2 probes are active on the vertical polarization. Those are located 45 degrees apart in azimuth, where each is transmitting one of the downlink (DL) streams faded with a Rayleigh sequence and an associated Doppler of 70 Hz. The DUT will be facing one of the probes. Although this configuration may not be realistic at all, its low complexity makes it suitable for debugging purposes while still keeping some interesting properties, such as time variant, fixed Doppler and fairly well conditioned MIMO channel matrix. Figure 4 contains an example of this testing. The same DUT is tested under the above mentioned channel for two different positions, twice each. Figure 3 shows the two positions used in the testing, that is, the phone is rotated 45 degrees from the vertical position, then Portrait (P) and Landscape (L) are the two possibilities.

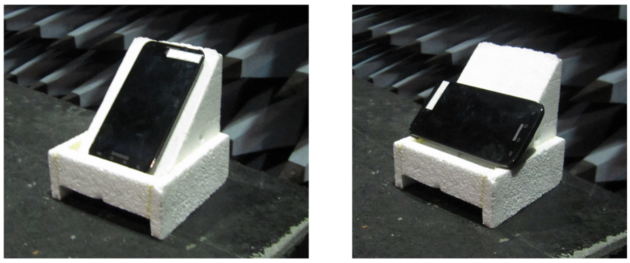

Fig. 3: Example of phone positioning. On the left S 45° Vertical, on the right S 45° Horizontal

Several conclusions can be extracted from Figure 4:

- It is clear that the number of blocks used for high MCS index (about 10.000 blocks) is not enough to have a stable throughput, however the difference between repetitions shows the convergence is good enough to get some meaningful results, plus the testing time is suitable to be used for debugging purposes.
- The degradation on the horizontal position suggest that the antennas on device 1A are vertical polarized with respect to its portrait position, however, the authors didn't have access to the antenna configuration inside the device.

The amount of curves per single measurement makes it difficult to compare several devices in one graph, therefore, assuming that the DUT can choose the optimal transition point between MCS and the network is fulfilling those requests, the maximum throughput at each SNR value can be displayed as an upper-bound of the device performance. This is used in Figure 5.

In Figure 5, one cluster SCM based channel is used mapped onto 8 or 16 vertical probes. This cluster will be coming from an Angle of Arrival (AoA) of 0 degrees (same direction as one of the probes) with an Azimuth Spread (AS) of 35 or 5 degrees. Likewise, the effect of a narrow AS with the degradation of the performance compared to the same DUT under the same cluster with a bigger AS is observed. It is also shown that the effect of 8 to 16 probes is negligible, which is coherent with [5] and [6]. Repetitions of the same test shows again that the system is stable.

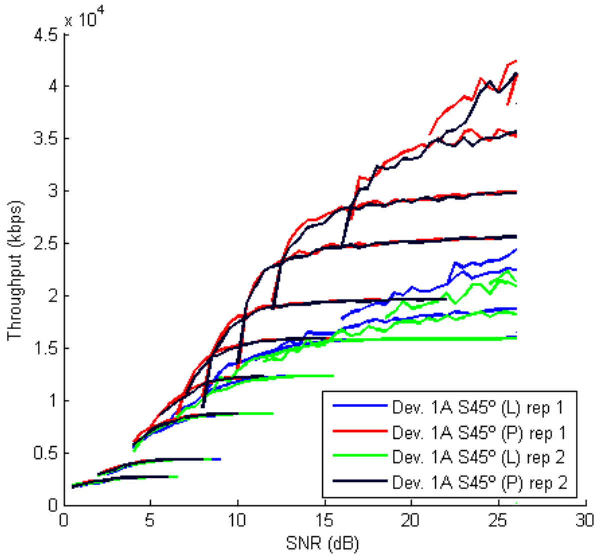

Fig. 4: Link Adaptation curves for device 1A under 2 different positions, calling mode and browsing mode

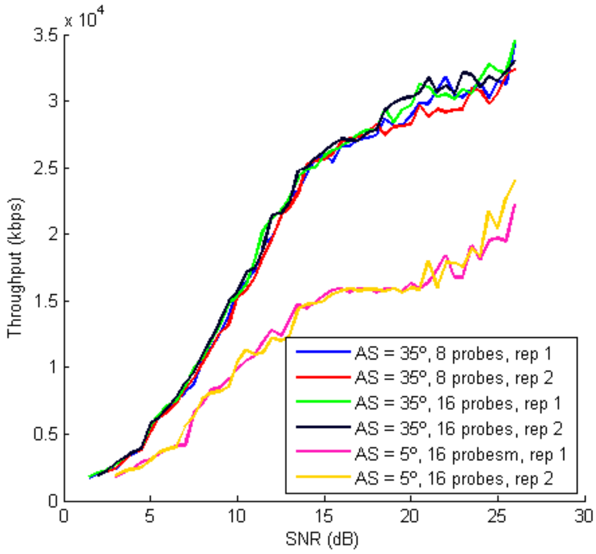

Fig. 5: Measurements results with device 1A under different SCM channels emulated with 8 or 16 probes

V. Conclusion

This contribution details the multi-probe anechoic chamber based MIMO OTA setup being built at Aalborg University. Afterwards, some results are shown on the impact of throughput performance for an LTE device under different conditions. The full paper will address the impact of channel profiles, DUT antennas, positioning of the phone and RF chipset implementation on the previously mentioned FoM.

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