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# LTE MIMO Throughput Measurement Method for Characterization of Multi-Antenna Terminal Performance

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**Abstract**—This paper presents experiences and results from LTE MIMO throughput measurements of a USB dongle in a reverberation test system. The measurements are performed with the dongle itself and also when it is connected to external diversity antennas with high and low correlation. Three different maximum bit rates are used, 59, 70 and 81 Mbps. The results illustrate that it is possible to separate a good antenna design from a bad from reverberation chamber measurements. Also, the effect of using a laptop test fixture, or a laptop dummy, instead of having the host computer present in the chamber, is demonstrated. It is shown that the noise induced by the host computer degrades the performance of the dongle.

**Keywords** - laptop test fixture; throughput; LTE; MIMO; reverberation chamber;

## I. INTRODUCTION

Long-term evolution (LTE) multiple-input-multiple-output (MIMO) communication systems are becoming more widespread and common for each year. Implementing the LTE MIMO technology in cellular phones and wireless modems (dongles) increases the data rates and the quality of the service. Therefore, there is an increased demand for accurate and repeatable ways of characterizing these systems. The test methods must be able to separate between a device with a good and a bad performance. The reverberation chamber is one of the methods proposed, since it offers an efficient and easy measurement procedure to do so.

A reverberation chamber is a metal cavity with electromagnetic reflective walls. By injecting an electromagnetic field in the chamber, and by stirring that field, the chamber can be used to generate a 3-dimensional Rayleigh fading environment [1] with an exponential decaying power delay profile. The signal received by a device placed in the chamber is similar to the faded signal received by the end-user equipment in a real multipath propagation environment, like urban and indoor environments [2]. In contrast to the real world, the chamber will be a repeatable facility. Because of this, the reverberation chamber has become an established tool for analysis and characterization of various antenna parameters,

such as radiation efficiency, impedance mismatch, diversity gain, MIMO antenna capacity, total radiated power (TRP), and total isotropic sensitivity (TIS). These measurement setups are well described in previous publications [3-6].

As LTE MIMO enabled test equipment and devices recently have become available, it has been possible to start the evaluation of the different test methods proposed for the LTE MIMO technology. This paper presents experiences from LTE MIMO throughput measurements performed in a Bluetest reverberation test system (Fig. 1). The measurements are performed with a USB dongle for three different maximum bit rates, 59, 70 and 81 Mbps. The dongle has connectors that are used to connect external diversity antennas with high and low correlation. Using this setup it is possible to see if a device with a good antenna design can be separated from a device with a bad antenna design, using the reverberation chamber.



Figure 1. Photo of a Bluetest reverberation test system RTS60 used in the presented measurements. Cavity size of the chamber is 1.75m x 1.8m x 1.2m.

One issue that arises when measuring the performance of USB dongles is the interference from the host computer. The amount of interference from the computer will depend on the laptop brand, model or even the specific unit at hand. A computer working with maximum performance will also give more noise than a computer in power-saving mode. Thus the measured performance of the dongle will be dependent on the specific host computer used and will not be the same if measured in different labs. One way to solve this problem is to use a so called laptop test fixture (LTF). This is basically a laptop dummy, which removes the interference from the host computer but works to keep the parts of the computer that are important for the optimized performance of the dongle (ground plane, mother board, etc.) intact. In this paper the effect of using such an LTF will be demonstrated.

## II. MEASUREMENT PROCEDURE

The measurements were performed in a Bluetest reverberation test system, series 6 (RTS60). This is a mode-stirred reverberation chamber, equipped with three transmitting antennas and other hardware and software that enable MIMO measurements. The chamber is also equipped with an optical USB interface that makes it possible to perform measurements without the host computer present in the chamber. There was no load in the chamber during the measurements and thus the delay spread was approximately 200 ns. Furthermore, an LTE enabled communication tester (CMW500 from Rhode & Schwarz) was connected to the RTS60. At the time of testing, this communication tester supported LTE MIMO transmission mode 3: Open loop spatial multiplexing. Fig. 2 shows a schematic picture of the measurement setup.

The throughput was measured for a fix output power and a continuous stirrer sequence with a sequence length of 30 seconds (50 samples à 500 frames). The measurements were performed on LTE band 7, downlink channel 2850 (2630 MHz) with a bandwidth of 20 MHz. More settings can be studied in Table I.

The dongle used in the measurements was a Samsung GT-B3730 and the host computer was an HP ProBook 6550b. In most of the measurements the host computer was placed outside the chamber and the dongle was connected to it via the chamber optical interface. Measurements were also performed with the computer present in the chamber and with a laptop test fixture (LTF). In the latter case the dongle was connected to the LTF, which in turn was connected to the optical interface (see Fig. 3). The LTF was an IBM 600E, where one of the USB ports was connected to an external USB cable and further connected to the USB interface in the chamber. The internal electronics of the LTF was disabled to avoid disturbing noise.

Moreover, the dongle has connectors that enable external antennas to be attached to it. These were used for connecting external multiport antennas with high correlation ( $>0.9$ ) and low correlation ( $<0.1$ ). The external antennas have been designed by Sony Ericsson to be used as MIMO

test phones and can be studied in Fig. 4. The low correlation antenna has two miniature ceramic BT/WLAN antennas put on each long-side of the pcb. These are from Pulse, type W3008c. For the high correlation a dual feed PIFA was used. The antennas were also used in previously presented measurements performed by NTT DOCOMO in [7], where additional antenna data can be found. Using this setup it was possible to see if a dongle with a good antenna design could be separated from that with a bad design from measurements in a reverberation chamber.

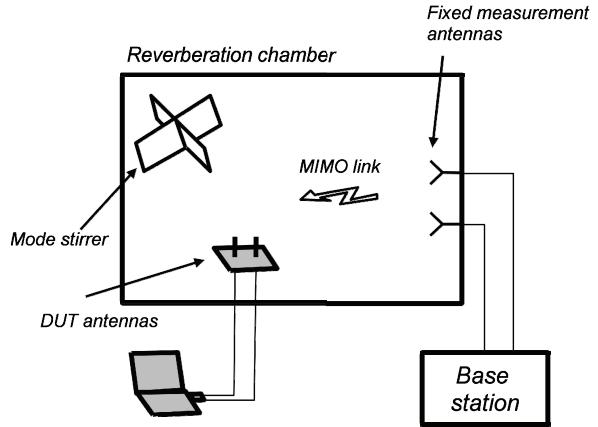


Figure 2. Schematic picture of the measurement setup for the LTE MIMO measurements in the RTS60.

TABLE I. THE SETTINGS USED FOR THE LTE MIMO MEASUREMENTS.

Parameter	Value
Downlink channel	2850 (2630 MHz)
Bandwidth	20 MHz
Modulation	64-QAM
Frames per sample	500
Number of downlink resource blocks	96
Transport block size index	15, 17 and 19 (= 59, 70 and 81 Mbps)
Connection type	User defined
Transmission mode	Open loop spatial multiplexing

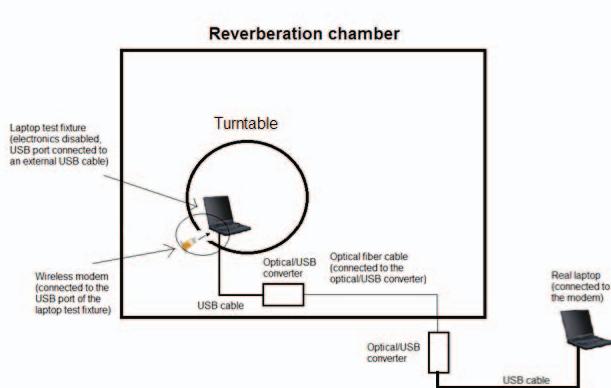


Figure 3. A schematic picture of the measurement setup for measuring throughput with a laptop test fixture connected to the USB interface in the RTS60.

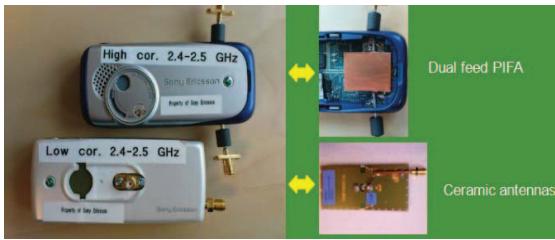


Figure 4. The external antennas with high and low correlation used in the measurements.

### III. RESULTS

This section presents the results of the LTE MIMO measurements in the Bluetest RTS60 system.

#### A. LTE MIMO measurements using different bit rates and external multiport antennas

Fig. 5 to Fig. 7 shows the results from the measurements using the external connected multiport antennas for three different bit rates; 59, 70 and 81 Mbps. As can be seen in the figures, the dongle always reaches the maximum throughput at higher power values. The throughput value is dependent on the external antenna used. The external antenna with high correlation gives a lower throughput for the same power value compared to the antenna with a low correlation. This is expected and shows that it is possible to separate a dongle with a good design from that with a bad design.

The figure also shows that the device is detaching when the throughput is about 40 – 60 % of the maximum bit rate. This might be due to an instable dongle or the instability of the communication tester. Regardless of the reason, this limits the throughput values that can be measured and thus the characterization of the dongle.

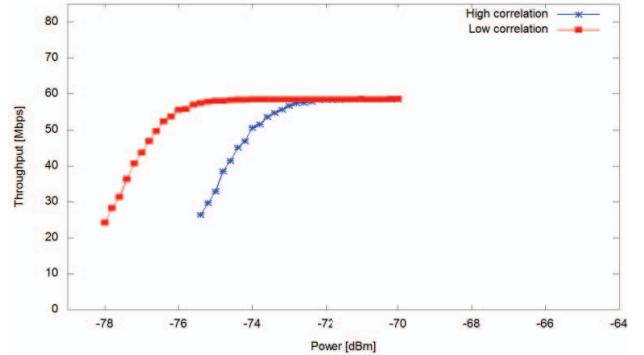


Figure 5. Results from the LTE MIMO throughput measurements with USB dongle in the Bluetest RTS60, using a maximum bit rate of 59 Mbps and two different multiport antennas. The setup with the high correlation antenna has worse performance than the setup with the low correlation antenna.

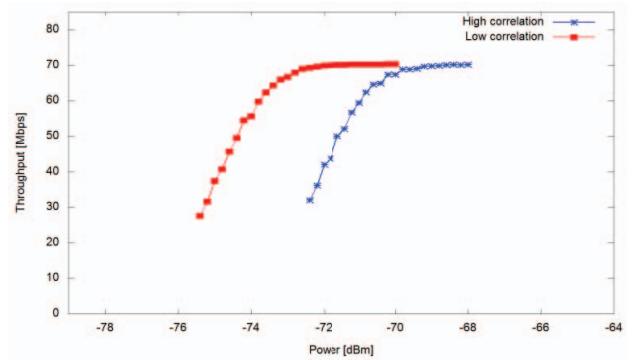


Figure 6. Results from the LTE MIMO throughput measurements with a USB dongle in the Bluetest RTS60 using a maximum bit rate of 70 Mbps and two different multiport antennas. The setup with the high correlation antenna has worse performance than the setup with the low correlation antenna.

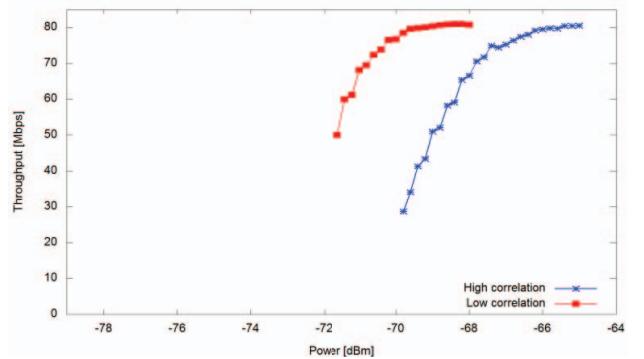


Figure 7. Results from the LTE MIMO throughput measurements with a USB dongle in the Bluetest RTS60 using a maximum bit rate of 81 Mbps and two different multiport antennas. The setup with the high correlation antenna has worse performance than the setup with the low correlation antenna.

### B. Repeatability

Fig. 8 shows the results from three and two repeatable throughput measurements with a maximum bit rate of 70 Mbps and 81 Mbps, respectively. For the first data rate the measurements were performed with the dongle connected to the LTF. In this case the LTF was removed and replaced in the chamber at approximately the same place. For the second data rate the dongle was connected to the external multiport antenna with low correlation. In this case the measurements were performed in different days, however without anything moved in the chamber. The same settings were used for the repeated measurements. It is clearly seen that the result is repeatable for both data rates.

### C. Reducing noise impairment by using a laptop test fixture

A comparison of the throughput values was also performed between connecting the dongle to an LTF and directly to the host computer present in the chamber. The maximum bit rate was 81 Mbps and the result can be studied in Fig. 9. The performance is seen to be about 2 dB worse with the host computer present and activated in the chamber. This indicates that the interference from the computer significantly affects the performance of the dongle.

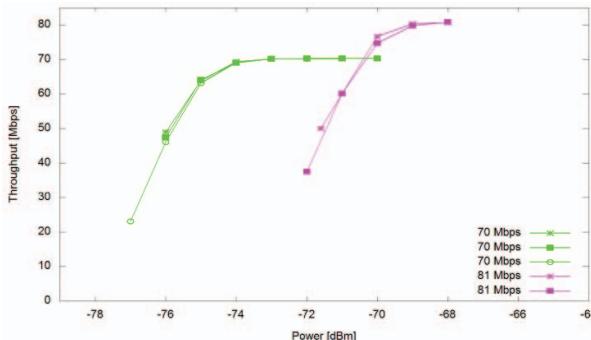


Figure 8. Results from three consecutive LTE MIMO throughput measurements with a bit rate of 71 and 81 Mbps. The dongle is connected to the laptop test fixture. The result is repeatable.

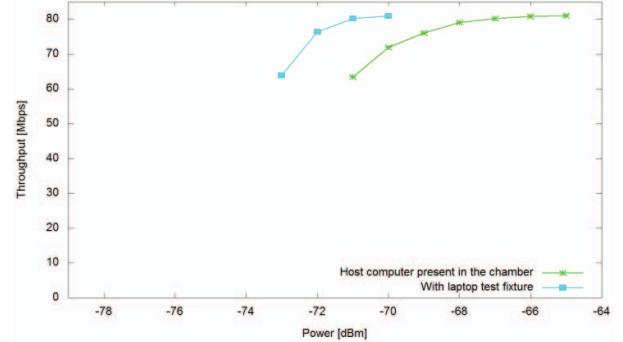


Figure 9. Comparison of the LTE MIMO throughput between connecting the dongle to a laptop test fixture and to a host computer present in the chamber. The maximum bit rate was 81 Mbps. The performance is approximately 2 dB worse with the host computer present in the chamber.

## IV. CONCLUSIONS

LTE MIMO measurements of a USB dongle has been performed in a Bluetest reverberation test system. Maximum bit rate was reached for all tested modulation and coding schemes. The measurements show that it is possible to see differences in performance when using different bit rates and to separate a dongle with a good antenna design from that with a bad design. Also, the results are repeatable. Finally, it is shown that the presence of the host computer in the chamber degrades the performance of the dongle compared to using a laptop test fixture.

## ACKNOWLEDGMENT

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