Spatial Fading Emulation Technique – OTA Throughput Measurements of Multi antenna reception terminals

Alessandro Scannavini[1], Lars J. Foged[1] , Meryam Abou El Anouar[2],
Nicolas Gross [3], John Estrada[4] , Francois Chauvet[5]

[1] SATIMO Italy, Via Castelli Romani, 59 00040 Pomezia Italy
ascannavini@satimo.com, lfoged@satimo.com
[2] SATIMO Bretagne, ZI du Vernis, 225 Rue Pierre Rivoalon 29200 Brest, France
meryam.abou-el-anouar@satimo.fr
[3] SATIMO Corporate HQ, 17, Avenue de la Norvège, 91953 Courtaboeuf cedex, France
ngross@satimo.fr
[4] SATIMO USA, 2105 Barrett Park Dr.,suite 104, Kennesaw GA 30144, USA
jestrada@satimo.com
[5] SATIMO Hong Kong, Suite 702, 7/F Cyberport 1, 100 Cyberport Road, Hong Kong
#francois.chauvet@satimo.*fr*

1. Introduction

New wireless standard protocols such as HSPA, LTE, and WiMax are employing multi-antennas on both the terminal and base stations sides. This technology, called Multi-input Multi-output (MIMO) enhance system performance especially in a strong multipath and fading environment. MIMO system performances are strongly dependent on antenna properties and the channel environment. MIMO and multi-antenna terminals cannot be reliably tested with the current Single Input Single Output (SISO) OTA (Over The Air) methodology [1], [2]. In multi-antenna communication systems, radio channel characteristics play an important role and SISO typical figure of merit do not take into account radio channel characteristics, and hence are not suitable for testing performances of multi-antenna terminals. 3GPP and COST2100 are looking for a standardized way for radiated performance testing [3], [4], [5], The Spatial Fading Emulation (SFE) technique relies on an anechoic chamber, antenna array, channel emulator, where a realistic multi-path propagation environments can be emulated in an anechoic chamber with a number of transmitting antennas surrounding the device under test (DUT), all transmitting simultaneously, and fed by a channel emulator. In this paper, overview of the SFE technique for testing multi-antenna terminals in a multipath and fading environment is presented. Practical consideration as well as results of a testing campaign will also be presented.

2. Measurement Set Up

Multipath and fading characteristics of a realistic propagation environment requires a controlled environment, such as an anechoic chamber with a multi-channel fading emulator and an array of probe antennas surrounding the DUT. Multi-channel fading emulator includes delay dispersion, fast fading, path delays, and doppler shift. The multipath signals are then transmitted to the DUT via probes. test plan has been proposed in [6] to provide laboratories with a test procedure to be followed in case the SFE technique will be used. The basic procedure consists in:

- Defining channel models parameters (Winner, SCM, SCME [7], [8], [9] standard channel models can be used)
- Creating channel impulse responses for the multi-channel fading emulator
- Calibrating system set up
- Setting up channel models power
- Executing the measurements

Due to the lack of both HSPA/LTE MIMO radio communication testers and test devices, OTA throughput testing has been performed on a HSDPA category 9 USB stick, with a 16QAM signal on the downlink. For the preliminary stage the channel models conditions are defined as following: the proposed test plan implements the SCME TDL (Tapped Delay Line) in two scenarios, Urban Micro (UMi), and Urban Macro (UMa) [7]. The angular spread for both scenarios follows a Laplacian distribution.

3. Calibration

The goal of the calibration process is to ensure identical responses from each antenna connected to independent channels (see Fig. 1). The calibration process consists on measuring the total path loss from the input of the channel emulator to the EUT location. Satimo sleeve dipole with known gain characteristics has been used as the EUT for the calibration. For this purpose, a one tap constant channel model is used to transmit through each probe individually, using the maximum amplitude in the fading profile. The process starts by sending a signal from each probe sequentially (1,3,5,7,9,11,13,15) to the EUT located in the center of the probes. The amplitude and phase response is then recorded via a VNA (Vector Network Analyzer), as depicted in Fig. 1. The weakest signal (higher path loss) will then be selected as the starting point for calibration. Compensation for the path loss differences is accomplished by adjusting the amplitude and phase weighting on the channel emulator for each output. The calibration process ends when the amplitude and phase adjustments have been stored on the channel emulator for each probe.

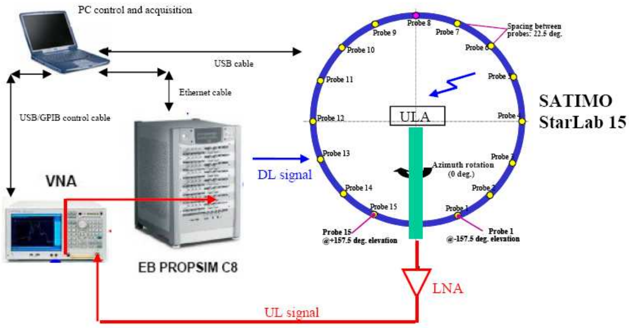


Figure 1: SATIMO – SFE calibration setup

Based on the proposed test plan, throughput in test mode is measured using three different power levels (-63dBm, -69dBm, and -75dBm). The power level refers to the measured power at the center of the probes when a constant channel model is transmitted via the probes. When testing an HSDPA device [10], downlink Modulation, fixed reference channel and HSDPA physical channel relative power should be chosen properly [10].

4. Measurement Results

The goal of the testing campaign is to estimate the accuracy of the channel models, and to validate the reference test setup. A Uniform Linear Array is used as the EUT. It is comprised of 3 dipoles with a resonant frequency of 2050MHz, spaced $\lambda/2$ apart.

First the spatial correlation has been measured and compared with theoretical values for angular spreads of 10° and 35°. It has been observed that the spatial correlation matches the theoretical values when the angular spread is equal to 10°, and tends to diverge for the higher angular spread of 35°.

Then a feasibility study has been led to understand if 8 probes are sufficient for generating a field at the center of the array with a distribution that matches the theoretical distribution that would be obtained from an infinite number of probes (a Bessel function of the first kind). A dipole has been stepped along the X-axis from -$\lambda/2$ to $\lambda/2$ with 1 cm steps. The impulse responses was recorded for each step using a VNA. Figure 2 shows the results of the comparison, and good correlation is observed between the two curves.

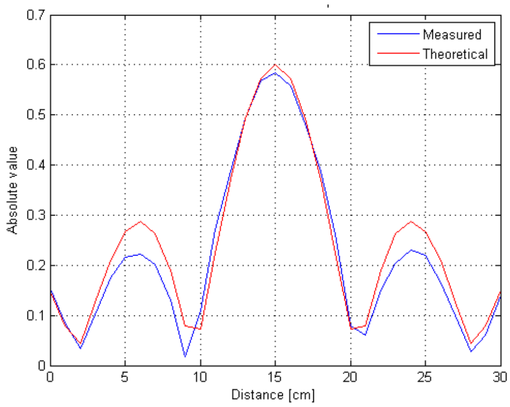
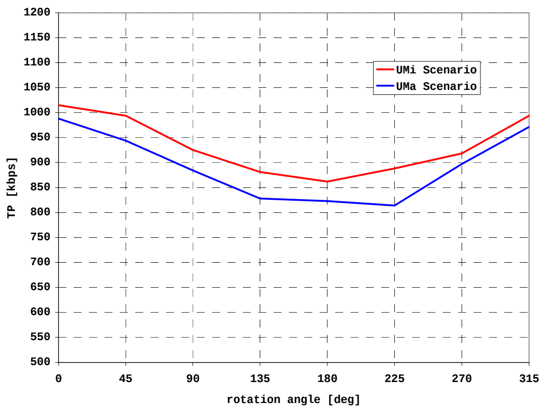


Figure 2: Feasibility region study

Finally tthroughput testing has been done with a configuration as shown in Fig. 1, except that the VNA has been replaced by a radio communication tester capable of setting up a WCDMA/HSDPA call. The downlink channel is set to 10562(low channel), the fixed reference channel to H-set 3, and the power of the HSDPA physical channel as per the table shown in Table. 9. The channel model power has been set to -63, -69, and -75dBm. A USB stick (HSDPA category 9) has been used as the DUT, and placed at the center of the probes. Throughput testing has been performed while rotating the DUT with 45° steps. In order to be consistent with the SFE set up where the probes are located on the phi plane, the channel models have been rotated on the test setup, instead of rotating the DUT. In Fig. 3 (left), throughput versus angle of rotation is shown with both the UMi, and UMa scenarios implemented. Average throughput versus channel model power is shown in Fig. 3 (right). The average has been calculated from the throughput results taken at each rotation step.



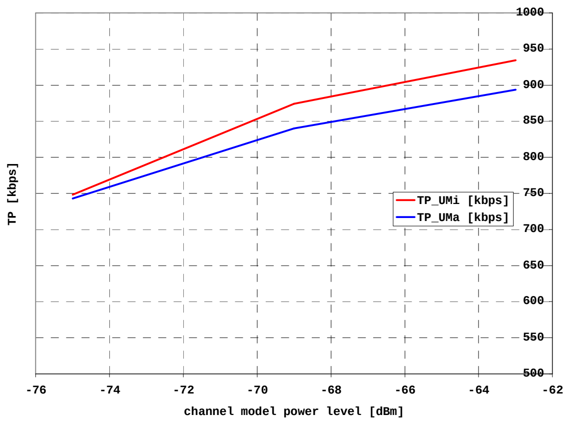


Figure 3: Throughput Vs rotation angle (left), Throughput Vs Channel model power (right)

5. Conclusions and Next steps

Attention was dedicated mainly to throughput testing. The results show that the throughput changes when rotating scenarios, highlighting the dependence of the DUT performance on the DUT's antenna configuration(i.e., radiation pattern dependence).

The feasibility study also shows that 8 probes are sufficient to generate a field at the center of the array with a distribution that matches the theoretical distribution that would be obtained from an infinite number of probes (a Bessel function of the first kind).

Further studies are planned to compare throughput results gathered from different laboratories using the same SFE technique in order to address accuracy and repeatability of results. The above assumes all the laboratories are going to follow the proposed test plan depicted in the present paper.

Further research is required to investigate the effects of using both polarizations of the probes in the multipath environment. In figure 4 StarMIMO is shown. It is the SATIMO's commercial solution based on SFE technique. It can be equipped with up to 32 dual polarized probes. Only 8 dual polarized probes will be used for the round robin testing as it was agreed in 3GPP RAN4 [11].

Figure 4: StarMIMO

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References

[1] 3GPP TR 25.914 v7.0.0 (2006-06), 3 rd Generation Partnership Project (3GPP); Technical Specification Group Radio Access Network, Measurements of radio performances for UMTS terminals in speech mode (Release 7), Tech. Rep., 67p.

[2] Cellular Telecommunication & Internet Association (CTIA), "CTIA test Plan for Mobile Station Over the Air Performance, Revision 2.2" , CTIA, Washington DC, Tech. Rep., Nov. 2006, 173p.

[3] Pekka Kyosti, et.al "OTA Testing for Multiantenna Terminals" , COST2100 TD (08)670, Lille France

[4] Joonas Krogerus, et al., "Towards an applicable OTA test method for multi-antenna terminals", COST2100 TD(08)671, Lille France

[5] Per O. Iversen, et al., "Radiated Perfromance Testing of Diversity and MIMO Enabled Terminals", COST2100 TD(08)618, Lille France

[6] Miia Nurkkala, et al., "Test Plan for OTA Throughput Measurements in a Fading Channel Environment", COST2100 TD(09)964, Wien Austria

[7] D.S. Baum, J. Hansen, G. Del Galdo, M. Milojevic, J. Salo, and P. Kyosti, "An interim channel model for beyond 3G system: extending the 3GPP spatial channel model (SCM)," in Proceedings of the 61st IEEE Vehicular Technology Conference (VTC '05), vol.5, pp.3132-3136, Stockholm, Sweden, May-June 2005.

[8] IST-WINNER II Deliverable 1.1.2 v.1.2, "WINNER II Channel Models", IST-WINNER2, Tech. Rep., 2008 (http://www.ist-winner.org/deliverables.html).

[9] V. Erceg, L. Schumacher, P. Kyristi, et al., "TGn channel models," *Tech. Rep. IEEE P802.11*, *Wireless LANs*, Garden Grove, CA. USA, 2004, http://www.802wirelessworld.com/8802

[10] 3GPP TS 34.121-1 v8.8.0 (2009-09), 3 rd Generation Partnership Project (3GPP), Technical Specification Group Radio Access Network, User Equipment (UE) conformance specifications, Radio transmission and reception (FDD), Part 1 Conformance specification (Release 8).

[11] TR 37.976 "Measurement of radiated performance for MIMO and multiantenna reception for HSPA and LTE terminals (Release 10)", version 1.1.0