Comparison of Measurement Accuracy and Time of TRP and TIS in Reverberation and Anechoic Chambers

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1. Introduction

The market for wireless technology is growing at a tremendous rate. Not only is the number of products within different market segments, e.g. mobile phones and WLAN equipment growing, but a large number of new types of wireless products are being introduced every year and also expected to experience rapid growth, for example RFID tags, TV game controllers like the Wii remote (Bluetooth), and home 3G base stations. The number of mobile phone users has passed 2 billion and will within a few years time pass 3 billion. About 1 billion new mobile phones are estimated to be sold in 2009 [1]. Most of these new products use small antennas. The Total Radiated Power (TRP) and Total Isotropic Sensitivity (TIS) of these devices have a direct influence on coverage, battery life time and bit rate in the up and down link. The TRP and TIS performance is very hard to estimate with software but relatively easy to measure. This is mainly due to the fact that small antennas are usually integrated in a chassis containing materials that absorb radiation or in different ways disturb the antenna function that are hard to model accurately. In a mobile phone there is furthermore a number of antennas that all affect each other. For small antennas the most important parameter to optimize is its antenna efficiency, i.e. the parameter that directly influences how much of the transmitter power is radiated into space, or how much of the radiation incident on the antenna reach the receiver. Since most of the small antennas must have high efficiency over a number of frequency channels and sometimes over several frequency bands, there is a need for a large number of measurements both during development and evaluation of wireless products. The faster a company can optimize the antennas in its wireless products, the faster the products can be released on the market to increase the competitiveness of the company. The traditional way of measuring antennas in anechoic chambers, i.e. without any reflections, is very good for large antennas that normally are used in a Line-Of-Sight (LOS) environment, but is a slow and unsuitable way to measure small antennas that normally are used in an environment with a lot of reflections, i.e. indoors or in an urban environment. Such an environment is much easier to simulate in a reverberation chamber. The reverberation chamber also have the advantage that it can be made much smaller and that the measurements are performed much faster than in an anechoic chamber. This paper will describe TRP and TIS measurements in Bluetest's High Performance (HP) reverberation chamber and give comparison to measurements of the same wireless devices in a CTIA approved anechoic chamber. It will be shown that the accuracy of the Bluetest chamber is similar to the CTIA approved anechoic chamber and that the measuerment times for TRP and TIS are between 3 - 20 times faster depending on type of test and communication protocol.

2. The Bluetest High Performance (HP) reverberation chamber

The reverberation chamber is a metal cavity which is large enough to support several cavity modes at the frequency of operation. The modes can be stirred to create a Rayleigh distributed transfer function between three fixed wall mounted antennas and the antenna under test inside the chamber. The reverberation chamber used in the present measurements is shown in figure 1. It has the dimensions 1.2m x 1.75m x 1.8m. The chamber makes use of platform stirring [2], and polarization stirring [3] to improve accuracy. Besides being an accurate and very fast instrument for TRP and TIS it is the only measurement instrument for direct measurements of diversity gain [4] as well MIMO capacity [5].

Figure 1: Photo (left) and sketch (right) of the Bluetest High Performance chamber.

The cost and space compared to an anechoic chamber is much smaller and the chamber is very easy to move from one room to another within the same building or between buildings.

3. The QuieTek CTIA approved anechoic chamber

The CTIA approved anechoic chamber at QuieTek is a fully anechoic chamber adopting the conical cut spherical scanning method [6] with a measuring antenna fixed on the robot measuring the field strength with varied theta angles emitted from the mobile phone under test with varied varied phi angles for TRP and TIS.

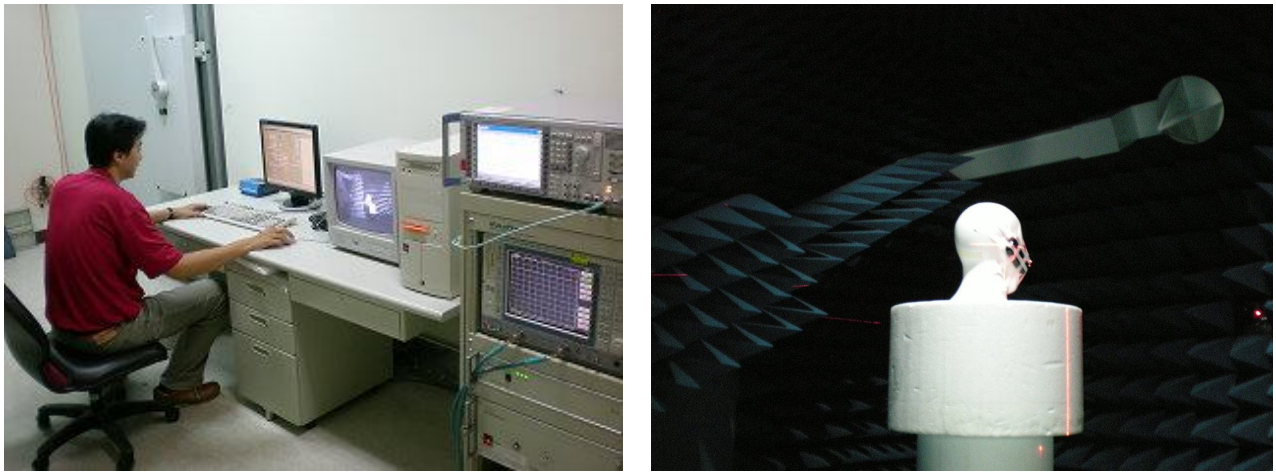

Figure 2: Total system (left) and mobile phone under test in chamber (right) of the QuieTek OTA CATL.

The chamber is shown in figure 2 with dimensions 5m x 4m x 4.5m where the distance between the measurement antenna and the center of the mobile phone under test is 1.384m. Styrofoam is used to support the mobile phone under test on the turntable. 264 measurement points per polarization is required for TRP measurement due to 15 degrees step and 60 measurement points per polarization is required for TIS measurement due to 30 degrees step. Besides fully meet with the CTIA OTA test plan requirements, 3D antenna pattern for those working in 700MHz-6GHz can be easily measured.

4. Measuring TRP and TIS in the Bluetest HP chamber

The Total Radiated Power (TRP) is the power that is transmitted, from for example a mobile phone, integrated over all directions. This power is affected by the output power of the amplifier, missmatch between amplifier and antenna, the antenna efficiency, objects in the vicinity to the antenna that contribute

with losses, for example mobile phone chassis, hand, head, etc. Similarly the Total Isotropic Sensitivity (TIS) is defined as the average received power collected over the whole sphere via the antenna and its associated losses, i.e. ohmic loss, mismatch loss between antenna and receiver as well losses caused by nearby objects like telephone chassis, user hand and head, etc. that correspond to a certain bit error rate (GSM, WCDMA), frame error rate (CDMA2000), block error rate (HSPA), etc. The measurement procedure for TRP and TIS is traditionally defined in a an anechoic chamber as a number of theta, phi positions over the sphere where a base station simulator is used to communicate with the terminal. For more information on the procedure to test TRP and TIS in an anechoic chamber see [6]. To measure TRP and TIS in a Bluetest chamber, the DUT, for example a mobile phone, is positioned on the turntable at least 0.5 wavelengths from any wall and at least 0.7 wavelenghts from any absorbing material. A base station simulator is connected to the three fixed antennas. It is now possible to initiate communication between terminal and base station simulator or vice versa. If a mobile phone is measured a special SIM card is normally used and after a call has been set up, the base station simulator orders the terminal to send at full power. The power between the mobile phone and fixed antennas is then measured. Since the base station simulator measure the recieved power and we know how large the chamber losses are from a previous reference measurement it is easy to calculate the TRP. To measure TIS in a Bluetest chamber, the test object is positioned in the same way as described above. After the call has been set-up, the base station simulator sends a bit stream at a given low power to the mobile phone and orders the mobile phone after it has received the bit stream to send it back at full power when it assumed that no further bit errors will occur on the up link. The base station simulator compares the received bit stream with the sent one. If the bit error rate is less than 2.4 % (example for GSM) the power from the base station simulator is successively lowered in steps until the power that corresponds to a bit error rate of 2.4 % is found. This power minus the losses in the chamber is the received power at a bit error rate of 2.4 %. This procedure is repeated for each mode stirrer position. By averaging all the measurements it is possible to calculate the TIS value.

5. Comparison of measurements in the QuieTek anechoic chamber and the Bluetest HP chamber

5.1 Accuracy comparison

Several mobile phones have been measured in both QuieTek´s CTIA approved chamber and the Bluetest HP chamber. Results from four mobile phones are shown in table 1.

Table 1: TRP and TIS for four mobile phones

GSM	QuieTek´s anechoic chamber		Bluetest HP chamber		Difference	
Freq. band	TRP (dB)	TIS (dB)	TRP (dB)	TIS (dB)	TRP (dB)	TIS (dB)
Phone 1						
1800 (ch 700)	26.8	-106.6	26	-105.8	-0.8	0.8
1900 (ch 661)	28.2	-106.9	26.8	-105.8	-1.4	1.1
Phone 2						
850 (ch 190)	29.4	-106.8	29.4	-106	0	0.8
1900 (ch 661)	26.8	-106.8	26.2	-106.9	-0.6	-0.1
Phone 3						
850 (ch 190)	23	-101.5	23.4	-100.5	0.4	1
1900 (ch 661)	26.8	-104.6	26.2	-103.1	-0.6	1.5
Phone 4						
900 (ch 975)	27.51	-104.38	27.47	-104.2	-0.04	0.18
1800 (ch 512)	26.13	-106.08	25.30	-104.60	-0.83	1.48
1900 (ch 512)	25.74	-105.47	24.64	-103.80	-1.1	1.67
WCDMA I (9750/10700)	19.13	-108.11	18.64	-107.40	-0.49	0.71

The agreement between measurements in QuieTeks CTIA approved chamber and the Bluetest HP chamber is good. If the standard deviation of both chambers is better than 0.5 dB one can expect 2 sigma differences of up to 2 dB, and the highest deviation is 1.4 dB in these measurements.

5.2 Time comparison

One of the major reasons to use the Bluetest HP chamber instead of anechoic chambers for measurments of TRP and TIS is measurement speed. Other reasons are chamber size and cost. In table 2 the measurement time for TRP and TIS for some communication standards are shown for the QuieTek CTIA approved anechoic chamber as well as anechoic chambers of some of Bluetests mobile phone manufactuer and operator customers and compared to the measurement times in the Bluetest HP chamber.

Table 2: TRP and TIS measurement times

Test chamber	Test time/channel	
Standard anechoic chambers	TRP (min.)	TIS (min)
QuieTek (GSM, WCDMA)	15	60
Bluetest customer X (GSM, WCDMA)	20	60
Bluetest customer Y (GSM, WCDMA)	5	20
Bluetest customer Z (GSM, WCDMA)	5	60
Bluetest customer Z (Bluetooth)	5	60
Bluetest HP (GSM, WCDMA)	1	6 - 12
Bluetest HP (Bluetooth)	< 3 for both TRP and TIS	

6. Conclusions

The TRP and TIS values obtained in the Bluetest HP chamber are in good agreement with the values obtained in QuieTek´s CTIA approved anechoic chamber. The test times in the Bluetest HP chamber are 5 - 20 times faster for TRP and 3 - 20 times faster for TIS compared to several different anechoic chambers. This will give users of the Bluetest HP reverberation chamber a significant time to market advantage when developing their wireless products.

References

[1] http://www.gartner.com/

[2] K. Rosengren et al., "Characterization of Antennas for Mobile and Wireless Terminals in Reverberation Chambers: Improved Accuracy by Platform Stirring", Microwave and Opt. Lett., vol. 34, no. 1, pp 56-59, July, 2002

[3] P-S. Kildal and C. Carlsson, "Detection of a Polarization Imbalance in Reverberation Chambers and How to Remove it by Polarization Stirring when Measuring Antenna Efficiencies", Microwave and Opt. Tech. Lett., vol. 34, no. 2, pp. 145-149, July, 2002

[4] M. Andersson, C. Orlenius, M. Franzén., "Very Fast Measurements of Effective Polarization Diversity Gain in a Reverberation Chamber", EuCAP 2007, Edinburgh, 2007.

[5] P-S Kildal, K. Rosengren, "Correlation and Capacity of MIMO Systems and Mutual Coupling , Radiation Efficiency, and Diversity Gain of their Antennas: Simulations and Measurements in a Reverberation Chamber", IEEE Communications Magazine, 2004.

[6] "Test Plan for Mobile Station Over The Air Performance" CTIA Certification, rev. 2.2, November 2006.