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3D Spherical Antenna Measurement System for CTIA OTA Testing and Characterizing of Mobile MIMO Terminals

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3D Spherical Antenna Measurement System for CTIA OTA Testing and Characterizing of Mobile MIMO Terminals

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Abstract

This paper describes the 3D spherical antenna measurement system for a passive antenna measurement, CTIA (Cellular Telecommunications & Internet Association) OTA (Over The Air) testing and characterizing of mobile MIMO (Multiple-Input Multiple-Output) terminals. The measurements of the monopole box are performed for the calibration of the proposed measurement system. Finally, the proposed system is able to measure the experimental model of MIMO terminal with adapting the diversity antenna system.

Keywords: Antenna measurement, CTIA, OTA, diversity antennas, mobile MIMO terminals, mobile communications.

1. Introduction

To predict and estimate the performance of antennas rapidly and accurately are important in mobile communications because the communication performance of mobile terminals is mainly determined by antennas. To investigate the performance of antennas, a passive antenna measurement is widely used in the handset development process. However, with considering the real environment, the passive one is not enough to ensure the acceptable sensitivity of mobile terminals because various factors in actual mobile terminals affect its sensitivity performance. Therefore, both a passive and an active antenna measurement should be considered to improve communication reliability. CTIA provides the guideline for OTA performance testing such as TRP (Total Radiated Power) and TIS (Total Isotropic Sensitivity). It is considered as standard evaluation criteria of AMPS, CDMA, TDMA, GSM, GPRS and EGPRS in the commercial service industry [1].

In MIMO wireless systems, the antenna diversity technique is used to reduce multi-path fading and to improve the mobile channel capacity. Applying this technique into the mobile terminals is a hot topic in antenna industry. Since there have no standard guideline unlike single antenna systems, the estimation of multiple antenna in mobile terminals has been arisen as the hot issue [2-4]. The purpose of this paper is to demonstrate 3D spherical antenna measurement system and to show the feasibility of passive and active measurement (CTIA OTA testing procedure) and a simple evaluation of an experimental model of the mobile MIMO terminal.

2. Spherical antenna measurement system

Three-dimensional radiation patterns are needed to calculate various parameters of antennas. Measurements and evaluation can be done by a spherical antenna measurement system. Largely, these systems are able to divide into 2 types; a distributed axis system, a combined-axis system.

The figure 1 shows the overall schematic diagram of the developed spherical antenna measurement system This system, which has the distributed axes for azimuth and elevation scanning, can measure three-dimensional radiation pattern for electrically small antenna in the far-field range directly. To measure the horizontal and vertical component of fields rapidly, a dual polarized horn antenna (ETS-Lindgren, 3164-04) is used as a probe with a SPDT microwave switch. Figure 2 shows the developed software that perform the role as user interface of the measurement system, motion control, data collecting, data post-processing, and the export function.

Also it can be able to extend CTIA OTA testing such as TRP, TIS with popular base station simulators, for example, Agilent 8960 and R&S CMU200. In addition, a diversity antenna system used in mobile MIMO terminals can be estimated in terms of spatial correlation, diversity gain, mean effect gain, and so on.

Because a gear or belt have an inherent backlash mechanically, a positioning error is inevitable. As the radius of rotation become larger, the cumulated positioning error is quiet large at the edge of rotation. To eliminate these errors, this system employs DDR (Direct Drive Rotator) at both azimuth and elevation axis. After fine-tuning of the measurement system, the precise positioning performance can be obtained.

The support bar for the elevation scanning of the probe is made of fiber reinforced plastic (FRP) to minimize reflection and perturbation and to guarantee

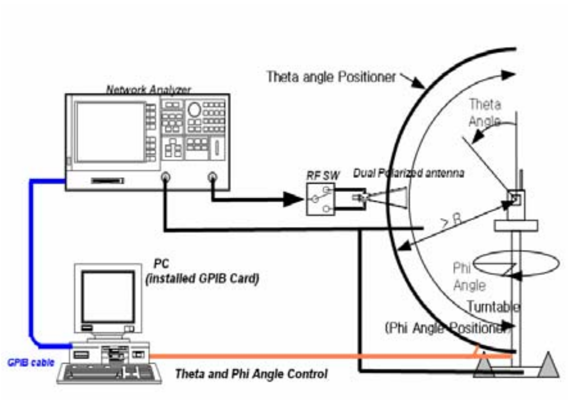
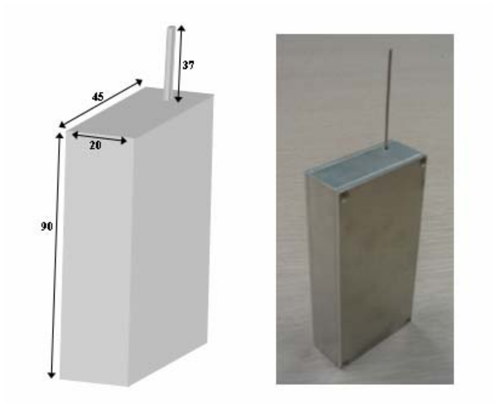


Figure 1. Spherical antenna measurement sytem

Figure 2. The developed SW of the measurement system



(a) **(b)**

Figure 3. The monopole box (a) dimensions, (b) picture (unit : mm)

the space between the elevation axis and AUT. Without any additional equipment, most of commercial bands can be measured using this system from 0.8 GHz to 6 GHz.

3. Measurement of the simple handset model and CTIA OTA testing procedure

The monopole box shown in figure 3 is used as the

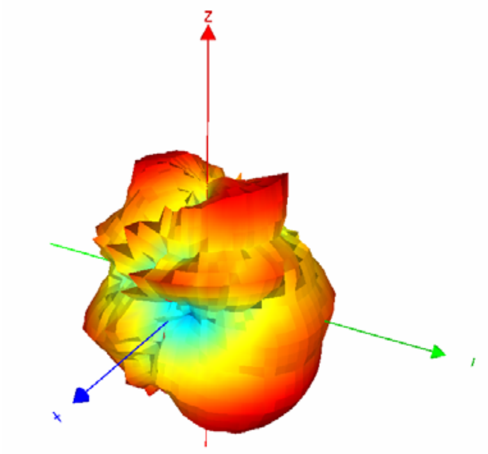


Figure 4. Measured 3D co-polarized radiation pattern of the simple handset model at 1.9 GHz

handset reference antenna. It is operating at 1.9 GHz and has typical radiation characteristics of a general monopole antenna. The measured results of the reference model are obtained in fully anechoic chamber.

Figure 4 shows the measured 3D co-polarized radiation pattern of the monopole box model at 1.9 GHz. The elevation plane is measured at the each discrete degree of 15° from 0° to 165°. Also the azimuth plane is measured at the same 15° from 0° to 360°. It doesn't measure the radiated value at 180° because of its mechanical limitation. However it doesn't affect the manipulated results such as gain, efficiency, TRP and TIS in discrete equation forms.

The measured result as shown in Fig. 4 has a typical tendency of a monopole antenna. Because the facility is not installed in anechoic chamber currently, a little of roughness in the measured radiation pattern appears.

Through measurements of 3D radiation patterns by the same way above, the values of TRP, TIS can be calculated using equation (1) and (2).

$$TRP = \frac{\pi}{2MN}\sum_{i=1}^{N-1}\sum_{j=0}^{M-1}[EIRP_\theta(\theta_i,\phi_j)+EIRP_\phi(\theta_i,\phi_j)]\sin(\theta_i) \quad (1)$$

$$TIS = \frac{2NM}{\pi\sum_{i=1}^{N-1}\sum_{j=0}^{M-1}[1/EIS_\theta(\theta_i,\phi_j)+1/EIS_\phi(\theta_i,\phi_j)]\sin(\theta_i)} \quad (2)$$

4. Measurement of the experimental model of the mobile MIMO terminal

In MIMO wireless systems, the antenna diversity technique is used to reduce multi-path fading and to improve the mobile channel capacity. Under multi-path environments like an urban and an office, the actual

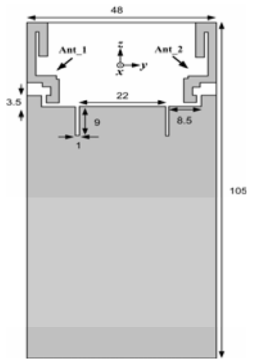


Figure 5. Geometry of the experimental model of the diversity antenna (unit : mm)

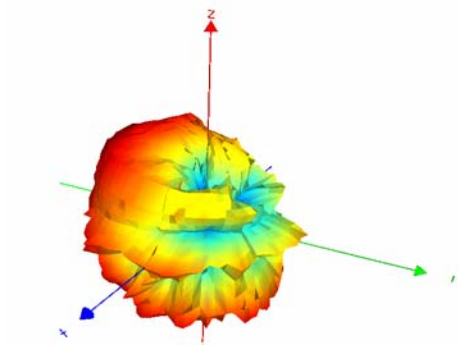


Figure 6. Measured 3D co-polarized radiation pattern of the antenna 1 of the experimental model at 5.15 GHz

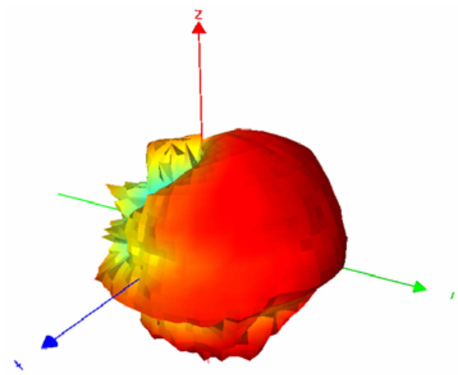


Figure 7. Measured 3D co-polarized radiation pattern of the antenna 2 of the experimental model at 5.15 GHz

channel capacity of the diversity antenna system can be evaluated statistically and spatially. But, an outside experiment is time-consuming work and influenced by a lot of factors. In addition, fast evaluation is necessary to overcome the development speed of the present mobile communication industry. To show measurement abilities, the experimental model designed for WLAN communications is demonstrated.

The geometry and dimensions of the experimental model are shown in Fig. 5. This model is a type of a printed planar monopole antenna, adapted to a PCMCIA (Personal Computer Memory Card International Association) network card for practical laptop applications [6].

The radiation patterns of the diversity antenna are measured by the developed 3D antenna measurement system. Figure 6 shows the measured 3D co-polarized radiation pattern at 5.15 GHz after the antenna 2 is matched to 50 ohm. Also, figure 7 shows the measured 3D co-polarized radiation pattern at 5.15 GHz after the antenna 1 is matched to 50 ohm. These results show how the diversity antenna system is operated spatially. In the multi-path environment, the signals arrived from the different directions can be received more well. Through measured results, some criteria can be calculated such as complex correlation and mean effective gain using [5, eq.1] and [5, eq.30].

5. Conclusion

This paper describes the developed 3D spherical antenna measurement system. It can perform the antenna measurement of 3D radiation patterns in the far-field region rapidly. This system can be applied to test CTIA OTA performance testing and estimate the spatial characteristics of the diversity antenna system.

References

[1] CTIA Certification Test Plan for Mobile Station Over the Air Performance, Method of Measurement for Radiated RF Power and Receiver Performance, Rev. 2.1 (2005).

[2] C. Braun, G. Engblom and C. Bechman, "Evaluation of Antenna Diversity Performance for Mobile Handsets using 3D Measurement Data," *IEEE Trans. Antenna and Propagation*, Vol. 47, pp.1736 – 1738 (1999)

[3] M. Karaboikis, C. Soras and V. Makios, "Compact Dual-Printed Inverted-F Antenna Diversity System for Portable Wireless Devices," *IEEE Antennas and Wireless Propagat. Lett.*, Vol. 3, pp.9 – 14 (2004).

[4] K. Ogawa, H. Iwai and N. Hatakenaka, "3D-Radiation Measurements of a Handset Diversity Antenna Close To a Realistic Human Phantom in a PDA situation," *IEEE Antenna and Propagat. Society International Symposium*, Vol. 2, pp. 1029 – 1032 (2003).

[5] T. W. C. Brown, S. R. Saunders and B. G. Evans, "Analysis of Mobile Terminal Diversity Antennas," *IEE Proceedings Microwave, Antennas and Propagation*, Vol. 152, pp.1 – 6 (2005).

[6] Y. S. Shin and S. O. Park, "Diversity Planar Monopole Antenna for WLAN application," submitted to *ISAPE* (2006)