

A Novel Test Bed for the Verification of SAS in the Complicated RF Environments

胡明雄、張道治

E-mail: 9315057@mail.dyu.edu.tw

ABSTRACT

The effects of multipath and co-channel interferences will increase the bit error rate (BER) and the root mean square (RMS) error vector magnitude (EVM) of communication system. All these effects will degrade the performance of communication system. In order to solve these problems, various kinds of smart antenna systems (SAS) are proposed in base transceiver system (BTS) for advanced communication system. For traditional SAS measurement, antenna pattern measurement system in anechoic chamber is used to measure the RF performances of SAS. The advantages of SAS are not easy to be verified in such RF anechoic chamber. In this paper, a general test bed in the real environment is developed for verifying the capability of SAS with modulated signal. The strong artificial co-channel interferences are generated by signal generator and the real complicated environment is used as the sources of multipath. The protocol of GSM, WCDMA, and IEEE802.11b are included in this thesis. The SAS is installed at the one axis rotation positioner to simulate the relative angular variation of mobile subscriber. The signals from the desired mobile subscriber, multipath, and co-channel interferences are received by the SAS. The RMS EVM value will be monitored during the azimuth rotation of SAS. If the RMS EVM value is larger, that means the effects of multipath and co-channel interferences are serious. In this situation, the beam pattern of SAS will be updated to get the lower RMS EVM value. Several kinds of multi-beams SAS and traditional BTS antenna are verified by the developed test bed. The test results show that the SAS will have the lower RMS EVM than that of traditional BTS antenna.

Keywords : smart antenna system ; bit error rate ; error vector magnitude

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REFERENCES

- 參考文獻 [1]Theodore S. Rappaport, " Wireless Communication, " Prentice Hall PTR, pp.177-248, pp.57-96, 2002.
- [2]Simon R. Saunders, " Antennas and propagation for wireless communication systems, " JOHN WILEY & SONS, INC., 1999.
- [3]Michael Chryssomallis, " Simulation of Mobile Fading Channels, " IEEE Antennas and Propagation, Vol.44, No.6, pp.10-22, December 2002.
- [4]Raymond Steele, Chin-Chun Lee, and Peter Gould, " GSM, cdmaOne and 3G System, " JOHN WILEY & SONS, INC., pp.154-167, 2001.
- [5]M. Chryssomallis, " Smart antennas, " IEEE Antennas and Propagation, Vol.42, No.3, pp.129-138, June 2000.
- [6]Fuhi, J and Molisch, A.F, " Capacity enhancement and BER in a combined SDMA/TDMA system " Vehicular Technology Conference, Mobile Technology for the Human Race., IEEE 46th , Volume: 3, 1996.
- [7]J. Li. Winters, " Smart antennas for wireless systems, " IEEE Personal Communications, Feb 1998, pp. 23-27.
- [8]J. S. Thompson, P. M. Grant, and B. Mulgrew, " Smart antenna arrays for CDMA systems, " IEEE Personal Communications Vol.3, No.5, pp.16-25, Oct. 1996.
- [9]J. E. Padgett, C. G. Gunther, and T. Hattori, " Overview of wireless personal communications, " IEEE Commun. Mag., vol. 33, pp. 28-41, Jan. 1995.
- [10]S. C. Swales, M. A. Beach, D. J. Edwards, and J. P. McGeehan, " The performance enhancement of multibeam adaptive base-station antennas for cellular land mobile radio systems, " IEEE Trans. Veh. Technol., vol. 39, pp. 56-67, 1990.
- [11]D. Shim and S. Choi " Should the smart antenna be a tracking beam array or switching beam array? " Proc. IEEE Veh. Tech. Conf., Ottawa, May 1998.
- [12]H. J. Xing, J. R. Cruz, and Y. Wang. " Fixed multibeam antennas versus adaptive arrays for CDMA systems, " IEEE VTC, 1999, pp. 27-31.
- [13]S. Choi, D. Shim, and Tapan K. Sarkar, " A comparison of tracking-beam arrays and switching-beam arrays operating in a CDMA mobile communication channel, " IEEE Antennas and Propagation, Vol.41, No.6, pp.10-22, December 1999.
- [14]M. Mahmoudi and E. S. Sousa, " Sectorized antenna system for CDMA cellular networks, " Proc.IEEE Veh. Tech. Conf., Phoenix, May 1997.
- [15]Mahmoudi, M.; Sousa, E.S.; Alavi, H. " Adaptive sector size control in a CDMA system using Butler matrix " Vehicular Technology Conference, Vol.2 , pp.1355 —1359, 1999.
- [16]Constantine A. Balanis, " Antenna Theory Analysis and Design, " JOHN WILEY & SONS, INC, pp.84~88, pp.841-844, 1938.
- [17]John D. Kraus, and Ronald J. Marhefka, " Antennas for All Applications, " McGraw-Hill Higher Education, pp.36-37, pp.838-840, 1910.
- [18]Joseph C. Liberti, JR. & Theodore S. Rappaport, " Smart Antennas for Wireless Communication, " Prentice Hall PTR, pp81~98, 1999.
- [19] " Using Vector Modulation Analysis in the Integration, Troubleshooting and Design of Digital RF Communication Systems, Compact and Broadband Microstrip Antennas, " HP Product Note, 89400-8, January 1994.
- [20] " 10 Steps to a Perfect Digital Demodulation Measurement, " HP Product Note, 89400-14A, July 1997.
- [21]Simon Haykin, " Communication Systems, " JOHN WILEY & SONS, INC., pp.309-337, 2001.
- [22] " Digital cellular telecommunications system (Phase 2+); Radio transmission and reception (GSM 05.05 version 8.5.1 Release 1999), " ETSI EN 300 910 v8.5.1, November 2000.
- [23]Dr. Adam Schwartz, " Metrics of Signal Quality for Digital Communication, " February 6, 2002.
- [24]Heung-Jae Im, Seungwon Choi, Jin Ho Ahn, and Kwang Chul Lee, " Implementation of a Smart Antenna Test-Bed for Wide-Band CDMA WLL Channel, " Vehicular Technology Conference Proceedings, Vol.1, pp.341-345, 2000.
- [25]Heung-Jae Im and Seungwon Choi, " Performance Analysis of Smart Antenna Test-Bed Operating in a Wide-Band CDMA Channel, " IEEE TRANSACTIONS ON MICROWAVE THEORY AND TECHNIQUES, VOL.49, NO.11, pp.2142 — 2146, NOVEMBER 2001
- [26]Yong-Hoon KIM, and Ki-Seok YANG, " 60GHz Millimeter-Wave Test Bed for High Speed and Wide Band Communications, " IEICE TRANS. ELECTRON., Vol.ES2-C, NO.7, pp.1301-1306, JULY 1999.
- [27]Perry F. Wilson, Peter B. Papazian, Michael G. Cotton, and Yeh Lo, " Advanced Antenna Test Bed Characterization for Wideband Wireless Communications, " Larry Irving, Assistant Secretary for Communication and Information, August 1999.
- [28]David M. Pozar, " Microwave Engineering, " JOHN WILEY & SONS, INC., pp.301-318, 2002.
- [29]張盛富, 戴明鳳, " 無線通信之射頻被動電路設計, " 全華科技圖書股份有限公司, pp.6.1-6.36, 2003.