

# Chapter 18

## Performance Evaluation of Full Diversity QOSTBC MIMO Systems with Multiple Receive Antenna

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### ABSTRACT

*Multipath fading is inherent in wireless communication systems. Diversity is the technique which takes advantage of multipath to mitigate the effect of fading and increase signal strength. Space Time Block codes (STBC) are used in MIMO systems to improve the performance by maximizing transmit and/or receive diversity. Among different schemes based on STBC, Quasi Orthogonal Space Time Block Code (QOSTBC) is able to achieve full rate transmission for more than two transmit antennas. Constellation Rotation QOSTBC (CR-QOSTBC) achieves full diversity and improves performance further along with full rate, to overcome the limitation of QOSTBC, which is unable to maintain orthogonality amongst the codes transmitted by different antennas. Higher diversity can be achieved by increasing uncorrelated paths between transmitter and receivers using higher number of receive antennas. This paper examines improvement in BER with reference to a number of receive antennas. Simulations were carried out under ideal as well as realistic environments, using least square technique with four antennas at transmitter side and variable receive antennas. Results of simulations presented in this paper indicate performance improvement of CR-QOSTBC over QOSTBC in flat fading channel environment. Simulation results also show performance degradation in BER when channel is estimated at the receiver.*

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## INTRODUCTION

Apart from channel noise, performance of wireless communication is also restricted by factors like multipath fading, as it affects correct reception of information. The increasing need for high data rate transmission over wireless channels has spurred much research effort into new communication technique, which has better resistance against multipath fading effects (Paulraj, Gore, & Nabar 2004).

Channel coding, Equalization and Diversity are main techniques for minimizing the effect of multipath fading (Sharma & Papadias, 2003). Multipath effects can be reduced using diversity without decreasing data rates and incurring expenditure in transmission time or bandwidth. Space diversity techniques rely on transmitting and/or receiving the signal over multiple independently fading paths in space. These kinds of systems employ more than one transmit as well as receive antennas creating Multiple Input Multiple Output (MIMO) systems. Apart from the diversity at the receiver the transmit diversity can be used by using different space time codes (Guey, Fitz, Bell, & Kuo, 1996; Alamouti, 1998; Tarokh, Seshadri, & Calderbank, 1998, 1999).

Initial Space time codes designed in form of Space Time Trellis Code (STTC) enjoy large diversity and coding gain simultaneously. However, they inherently involve Viterbi decoders causing large decoding complexity with the transmission rate and diversity order. This discourages the use of large number of transmit antennas (Dalton & Georgiades, 2005). To minimize its decoding complexity, Alamouti has proposed STBC scheme (Alamouti, 1998). The orthogonal structure of code matrix in Alamouti scheme offers full diversity when complex symbol wise Maximum Likelihood (ML) decoding is applied. Alamouti scheme generalized later on for more than two transmit antennas, is called orthogonal STBC (Zheng & Burr, 2003). OSTBC scheme provides full diversity because of its orthogonal design.

Unfortunately, OSTBCs suffer from a reduced code rate when complex signal constellations and more than two transmit antennas are used (Zheng & Burr, 2003; Ganesan & Stoica, 2001; Lu, Fu, & Xia, 2004).

Therefore, STBC designs that can achieve full transmit diversity and a higher code rate is desirable. Quasi Orthogonal STBC (Jafarkhani, 2001) is the structure that offers full rate but partial diversity. Eliminating the disadvantage of partial diversity, constellation rotation of complex symbols is performed and the modified technique is known as Constellation Rotation Quasi Orthogonal STBC (Tirkkonen, 2001; Weifeng & Xiang-Gen, 2004; Liang & Huaping, 2005).

Performance of CR-QOSTBC has been evaluated previously (Sharma & Papadias, 2003). We investigate the performance of CR-QOSTBC MIMO systems. Simulations were carried out for different combinations of SNR and number of receive antennas to observe impact on BER over *flat fading* channels with QOSTBC and CR-QOSTBC. Results of simulations indicate that BER performance of CR-QOSTBC improves with multiple receive antennas. We also discuss relative performance of CR-QOSTBC with respect to QOSTBC for different number of antennas.

The results are observed with the assumption that *channel state information* (CSI) is perfectly known to the receiver, which is not true in real environments. Various channel estimation techniques have been proposed in literature to measure CSI at receiver (Portier, Baudais, & H  lard, 2004; Sand, Raulefs, & Auer, 2005). The simulation results of QOSTBC and CR-QOSTBC schemes with Least Square (LS) channel estimation method is presented in this paper.

Rest of the paper is organized as follow. Various Space-Time Block Code schemes are presented. We describe the theory of CR-QOSTBC. The simulation results and discussion of observation are presented and finally, conclusions are drawn.

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