



Design of Space-Time Coded Single-Carrier and Multi-Carrier MIMO-CDMA systems

P. Sreesudha, Dr. B.L. Malleswari

Assistant Professor, Department of ETM, GNITS, Hyderabad, India

Principal, SWEC, Hyderabad, India

ABSTRACT: CDMA is one of the channelization protocols that support more number of users simultaneously and asynchronously. Uses spreading technique that spreads information bearing signals, so that only intended receiver can able to receive it thus provides security. MIMO technology has been widely used in wireless communications provides higher data rate and reliability. In this paper single and multi carrier CDMA systems with multiple antennas has been implemented with Space-Time Coding technology (STC) and simulation results are shown. Rotated QSTBC is outperforming for both single and multi carrier systems.

KEYWORDS: MIMO, CDMA, MC-CDMA, space time coding, quasi-orthogonal space time block code.

I. INTRODUCTION

Multiple antennas play an important role in improving radio communications. In this technique two key related aspects are discussed. They are of multiple antenna communication systems, in these systems multiple access interference mitigation at the receiver via multi-user beam forming and space-time modulation and coding for MIMO systems [3]. Space-time codes are capable of extracting spatial diversity gain in systems employing multiple antennas at the transmitter and receiver that is multiple-input and multiple-output (MIMO) without requiring channel knowledge in the transmitter.

Multicarrier systems convert a high rate data stream into multiple parallel lower data rate sub streams, and each modulated symbol will be carried on a different subcarrier. And multi-carrier system uses one of the emerging technologies OFDM which combats the multipath fading effects. In this paper Rayleigh channel has been implemented for MIMO-CDMA systems.

II. RELATED WORK

Wireless communication systems in the next generation technologies are required to have high voice quality and also need to provide higher data rates. At the same time they need to operate in different types of environments also. In [1] the author has proposed maximal ratio receive combining scheme and he also proposed new transmit diversity scheme with two branch transmit diversity with one receiver and two branch diversity with M receivers. The scheme achieves full diversity for 2x2 antennas. In [3] MIMO-CDMA system performance is analyzed with Monte Carlo simulations. In [5] the author has designed space time block codes with real and imaginary cases. And STBC is designed with a matrix. And provides orthogonality among the symbols. In [7] author has designed MIMO-CDMA system with space time block codes. In this design permutation spreading method is used for selection of spreading sequence. And each user needs eight spreading sequences in this scheme. In [8] author has proposed multi-carrier CDMA system with STBC and QSTBC codes, and the system performance is improved by using constellation rotation.

III. SYSTEM MODEL

MIMO-CDMA system block diagram has been shown in Fig 1. In the figure first the data which is to be transmitted is given to serial to parallel block converter. After that the data is modulated with BPSK modulation then it is spreaded with PN spreading sequence.

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Finally the spreaded data will be transmitted through multiple antennas. At the receiver side multiple receiving antennas are used. Each antenna receives the data from all transmitting antennas. Bank of matched filters are used to receive the exact signal.

The output from all these matched filters is given to decision threshold device, which performs maximum likelihood detection algorithm in order to retrieve the original bit stream.

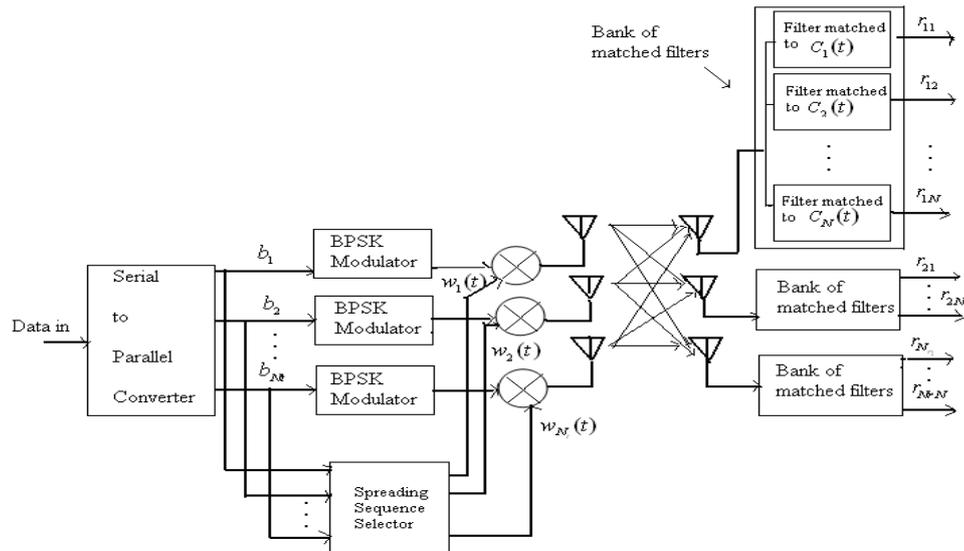


Fig. 1. Block diagram of MIMO-CDMA system

IV. MIMO-CDMA WITH STC CODING

Space-time coding is a new paradigm in the wireless communications that improves the reliability and efficiency. And it works with multiple antennas. STC is two types. One is Space Time Trellis Code (STTC) and other one is Space Time Block Code (STBC). In this paper the system is developed with Space time block codes.

Space-time block coding is a new technique which provides reliable data transmission with multiple antennas. In MIMO scheme multiple antennas are used and STBC codes generate the code symbols which are equal to the number of transmitting antennas that are used in MIMO transmitter. STBC decoding also very simple, it uses linear decoding procedure. Main aim of this technique is improves the BER performance. As compare to STTCs this mechanism provides better performance. Because in STTC decoding process is complex.

A. MIMO-CDMA with OSTBC Codes

In this algorithm 4 transmitting antennas are used at the transmitting side. The data is converted into parallel first and then spreaded with PN sequences. STBC provides orthogonality among the coded symbols, so that interference will be reduced among the antennas and symbols. At the receiver side channel gain is added to the symbols. And matched filter forms detection and retrieves original data.

B. MIMO-CDMA with QSTBC Codes

In this algorithm MIMO-CDMA system has been implemented with Quasi Orthogonal Space Time Block Codes (QSTBC) codes. In the STBC technique stbc codes allows orthogonality among coded symbols, but it cannot achieve full rate diversity. Full rate diversity can be achieved only with alamouti scheme with two transmitting and two receiving antennas.

As the number of transmitting antennas increased it cannot allow full diversity. So in order to avoid that limitation QSTBC codes are used. QSTBCs are designed with quasi orthogonal method, where the generated symbols from the multiple antennas are arranged in such a way that, in the QSTBC matrix only few columns have orthogonality. But

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these codes provide better ber performance compared to STBC codes. Fig. 2 shows QSTBC matrix. For this matrix orthogonality criterion only holds for columns (1 and 2), (1 and 3), (2 and 4) and (3 and 4).

$$C_{4,1} = \begin{bmatrix} c_1 & c_2 & c_3 & c_4 \\ -c_2^* & c_1^* & -c_4^* & c_3^* \\ -c_3^* & -c_4^* & c_1^* & c_2^* \\ c_4 & -c_3 & -c_2 & c_1 \end{bmatrix} \quad (1)$$

Fig. 2. QSTBC matrix

C. MIMO-CDMA with Rotated QSTBC Codes

In this algorithm the system is implemented with Quasi Orthogonal Space Time Block Codes with constellation rotation. And, qstbc matrix is used to implement this with a rotation angle. At the receiver side ML(Maximum Likelihood) equalizer has been used for detection process. QSTBC implementation achieves full diversity but the performance is good only at lower signal to noise ratio (SNRs) values. For higher SNRs performance is low compared to OSTBCs. So in order to overcome this limitation then new technique has been introduced.

In this new scheme half of the symbols in a quasi-orthogonal design are chosen from a signal constellation set \tilde{A} , and the other half of them are taken from a rotated constellation $e^{j\phi}\tilde{A}$. The new STBCs can guarantee both full diversity and performance.

V. MIMO-MC-CDMA WITH STC CODING

MC-CDMA system combines the advantages of OFDM and CDMA technologies. Instead of using single carrier system multiple carrier's offers better performance. The technique provides robustness to frequency selective fading channels. MIMO-MC-CDMA system block diagram has been shown in Fig2.

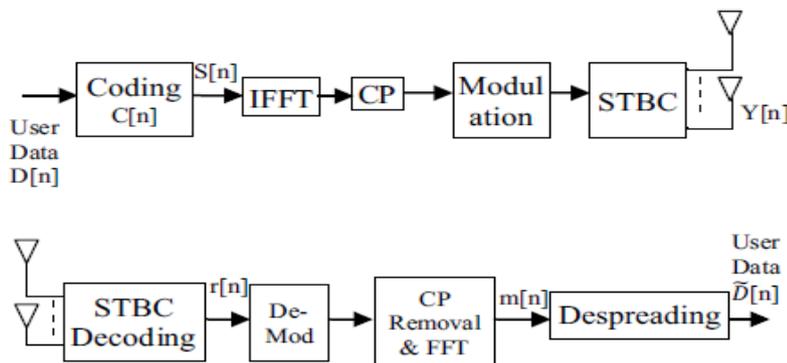


Fig. 3. MIMO-MC-CDMA block diagram

A. MIMO-MC-CDMA with OSTBC Codes

The data source is serial to parallel converted then spreaded with PN sequence. The spread data is given to IFFT block for generating orthogonal subcarriers, then cyclic prefix is added to avoid interference between antennas. The output from IFFT block is given to BPSK modulator and then is coded using Space time block code matrix. The data is transmitted using multiple transmit antennas.

At the receiver side multiple antennas receives the data from transmitting antennas and is given to detecting mechanism for detecting symbols by combining them. Then the decoded output is demodulated and then CP is

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removed. After that the symbols are given FFT process then finally despread with the same PN sequence. The output is parallel to serial converted.

B. MIMO-MC-CDMA with QSTBC Codes

In this algorithm the system is implemented with 4 transmitting and 4 receiving antennas. Quasi orthogonal space time block codes are used in this. Here also similar mechanism, qstbc matrix is used to implement this. At the receiver side ML equalizer has been used for detection process.

C. MIMO-MC-CDMA with Rotated QSTBC Codes

In this algorithm the MC-CDMA system implemented with 4 transmitting and 4 receiving antennas along with rotation angle. Quasi orthogonal space time block codes provide full diversity by using constellation rotation. And the system shows better performance than QSTBC.

VI. SIMULATION RESULTS

In this paper MIMO-CDMA system with 4x4 antennas with STBC and QSTBC codes has been implemented. And the system has been implemented with multi carrier also. The simulated results are shown below. BER performance of MIMO-CDMA system with STBC and QSTBC codes for 4x4 antennas case result is shown in Fig. 4. In the Fig.4 the QSTBC is giving better performance. In the Fig. 5. the simulated graph is shown for MIMO-CDMA with rotated QSTBC same 4x4 antennas. And it is observed that rotated QSTBC is giving better ber value compared to both STBC and QSTBCs. Similarly MC-CDMA system with QSTBC and rotated QSTBC simulated output is shown in Fig. 6. And it is clearly observed that rotated QSTBC is giving better performance in both single carrier and multicarrier systems.

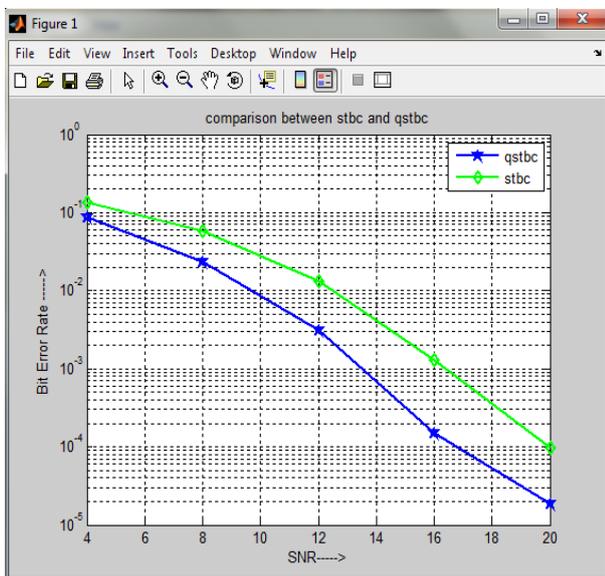


Fig. 4. MIMO-CDMA with STBC and QSTBC for 4x4 antennas

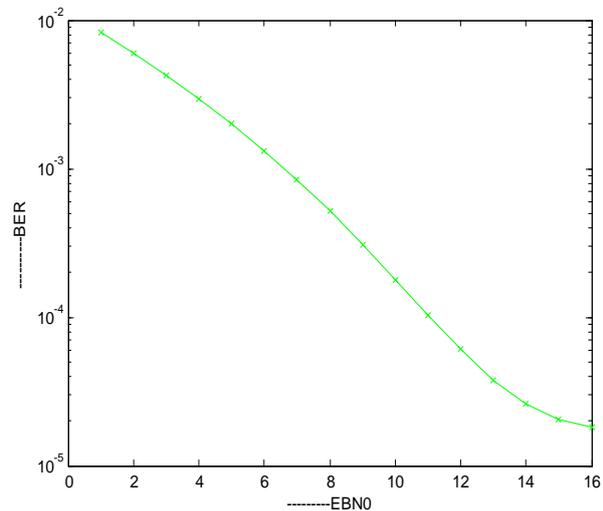


Fig. 5. MIMO-CDMA with rotated QSTBC for 4x4 antennas

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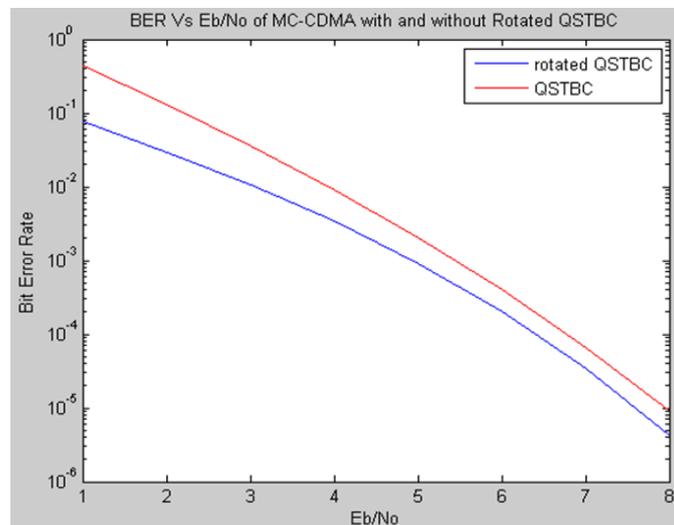


Fig. 6. MIMO- MC-CDMA with rotated QSTBC and QSTBC for 4x4 antennas

VII. CONCLUSION AND FUTURE WORK

In modern wireless communication systems CDMA plays a very important role and is ideally suited for mobile cellular network. Space-time coding is a new paradigm in modern wireless communications which improves the efficiency and reliability along with the multiple antennas. It provides spatial diversity that combats fading which is a major impairment in the wireless communications. And the next generation cellular communication system is MC-CDMA. MC-CDMA includes the advantages of CDMA and OFDM. In this paper the Single-Carrier CDMA system has been implemented with 4 transmitting and 4 receiving antennas. The technique implemented for multi-carrier system also. Among all the results QSTBC with rotated constellation is outperforming in both single-carrier and multi-carrier systems.

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BIOGRAPHY

P. Sreesudha working as an Assistant Professor in Electronics and Telematics Engineering Department, GNITS, Hyderabad, India. Currently doing research work on MIMO-CDMA technologies. Her areas of interest are MIMO, CDMA, and OFDM.