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Performance Comparison of STBC & STBC-SM with Various Modulation Techniques

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ABSTRACT—*Antenna technology in wireless communication uses diverse antennas at the transmitter and receiver side to exchange information. A new emerging technology called MIMO (Multiple Input Multiple Output) is generally used as antenna technology. MIMO gives rise to problems with multipath effect. Due to this interchannel interference or intercarrier interference occurs. To deal with problems of multipath effects a key emerging modulation called spatial Modulation is used. This new technology, spatial modulation when combined with high rate space time block code reduced BER of overall system. Hence both core STBC and antenna indices carry information over multiple paths. In this paper, STBC with BPSK, QPSK & QAM modulation techniques and also STBC-SM with BPSK, QPSK & QAM modulation techniques is designed which has low BER than STBC system. STBC-SM scheme can be useful for high rate, low convolution and prominent wireless communication system such as LTE & Wi-max. This paper presents the simulation results of 2 transmit and 2 receive antennas of Alamouti Scheme.*

KEYWORDS: *Space-Time Coding (STC), Multiple Input Multiple Output (MIMO), BPSK, QPSK, QAM, Spatial modulation, STBC-SM*

I. INTRODUCTION

MIMO system consists of diverse antennas at both the transmitter and receiver side. The principle goal of MIMO technology is to improve either the quality (BER) or the data rate of the communication by means of adequate signal processing techniques at both ends of the system. MIMO can acquire both multiplexing &diversity gain thus remarkably enlarges the system capacity as well as improving the reliability of the wireless link. The advantage of MIMO communication can be divided into three main categories: Spatial multiplexing for enhancing the data transmission rate, transmit diversity using space time coding. One inherent issue of the wireless channel is fading, which occurs as the signal travel diverse paths between the transmit and receive antennas. In this case no reliable communication is possible. Fading can be mitigated by diversity or spatial multiplexing which means that the information is transmitted not only once but several times, hoping that at least one of the replicas will not undergo severe fading[1].

As a performed analysis two standard MIMO transmission strategies, a space-time block coding (STBC) and spatial multiplexing(SM), have been proposed. The increasing demand for high data rates and high spectral efficiencies has led to the development of spatial multiplexing systems [2].

The rest of this paper is organized as follows. In section 2 present the related work of STBC-SM system. Section 3& 4 give brief introduction about space time block code & spatial modulation respectively.Section 5 represents methodology & proposed work of this paper. Section 6 gives basic idea of STBC-SM system. Finally in section 7 & 8 results & conclusion are given.

II. RELATED WORK

Multiple input multiple output (MIMO) systems give higher spectral efficiency and better performance without consuming extra bandwidth and power. Recent developments in the MIMO technologies focus on reducing computational and hardware complexity using different transmit and receive diversity schemes.

Alamouti proposed a simple two branch transmit diversity scheme. It was thenexaminedas space time block codes (STBC) for number of antennas and analyzed spatial modulation (SM) in which antenna index of the active antenna also carries the information resulting in increased spectral efficiency. SM systems are further investigated and a joint detection scheme is proposed to improve the performance in. SM system can be combined with STBC system to get two fold advantages of improved performance and better spectral efficiency.

NaziaParveen& D.S. Venkateswarlu [1] present the Simulation results of 2 transmit and 2 receive antennas of Alamouti Scheme. This paper provides a basic overview of MIMO system, space time block coding. Thus they observed that BPSK modulation for 2x2 Alamouti STBC give better better for SNR of 13db with BER of $1.1e^{-0.005}$ when compare to MRC the Almouti scheme.

K.Bala,Murali Krishna & G. Ramesh Babu [2]give brief introduction about STBC-SM system design and its optimization. They present optimal ML decoder for the STBC-SM system.They give BER analysis for 4*4 MIMO systems using different modulation techniques and conclude that STBC-SM gives better BER as compared to other modulation techniques [2].

Santumon.S.D& B.R. Sujatha[3] in this paper present the Space-Time Block Codes (STBC) for wireless networks that uses multiple numbers of antennas at both transmitter and receiver. Author simulates the Alamouti scheme performance with coherent BPSK modulation. They give BER curves for the Alamouti scheme for QPSK and QAM modulations in Rayleigh channel.

III.SPACE TIME BLOCK CODE

Space–Time Block Codes (STBCs) are the elementary sets of spatial temporal codes that utilize the diversity present in systems with number of transmit antennas[1].Space-time block codes (STBC) are a generalized version of Alamouti scheme. These codes are orthogonal and can achieve full transmit diversity specified by the number of transmit antennas. In other words, space-time block codes are composite design of Alamouti space-time code, where the encoding and decoding schemes are the same as there in the Alamouti space-time code on both the transmitter and receiver. The data are assembled as a matrix which has its columns equal to the number of the transmit antennas and its rows equal to the number of the time slots required to transmit the data. At the receiver side, the received signals are first merged to form a single unit and then sent to the maximum likelihood detector where the decision rules are applied. Space-time block codes were planning to accomplish the maximum diversity order for the given number of transmit and receive antennas subject to the constraint of having a simple linear decoding algorithm [3].

IV. SPATIAL MODULATION

A novel concept known as spatial modulation with space time block code is used to remove the interchannel interference completely between the transit antennas of MIMO link. The primary idea of spatial modulation is to prolong of two dimensional signal constellations (such as M-ary phase-shift keying (M-PSK), M-ary quadrature amplitude modulation (M-QAM), where M is the constellation size) to a third dimension, which is the spatial (antenna) dimension. Consequently the information is conveyed by both amplitude/phase modulation (APM) techniques and antenna indices[4]. Alamouti code which is Space time block code does not need channel state information or knowledge of channel coefficient.

V. PROPOSED WORK

Methodology

In this paper, we implement STBC Alamouti scheme with two transmit, two receive antenna over Rayleigh fading channel using BPSK, QPSK & 16-QAM modulation technique. Afterwards we also implement STBC-SM scheme with BPSK, QPSK and 16-QAM modulation technique. For decoding Alamouti code, there are several method like zero forcing, minimum mean square estimation (MMSE), Brute force ML decoding etc.

Best performance is given by Brute force ML decoder.Finally BER vs. SNR simulation results are compared between STBC & STBC-SM techniques.

System Model

The Alamouti code is the prime STBC that yield full diversity at full data rate for twoor more number of transmit antennas. A block diagram of theAlamouti space-time encoder is shown in figure 5.2.1[5].

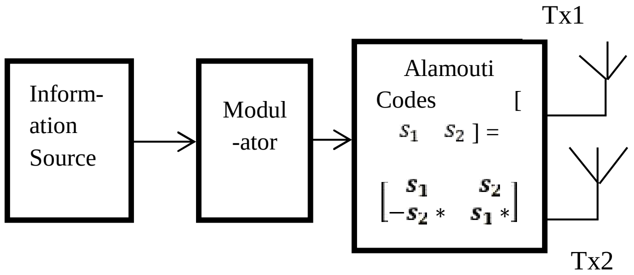

Figure5.2.1: Block diagram of space time encoder

Here the information source to be transmitted is modulated and fed to the space time encoder. The space time encoder consists of two transmit antennas as part of the multiple input multiple output technology [3]. So here the information is transmitted through two separate antennas. Each transmitting and the receiving antenna pair has a channel, represented by different channel coefficients. These channel coefficients play a major role in the design of the system.

In the encoder is the two modulated symbols S_1 and S_2 in each encoding operation and sent up to the transmit antennas in the form of a matrix as follows:

$$S = \begin{bmatrix} s_1 & s_2 \\ -s_2^* & s_1^* \end{bmatrix}$$

The first row indicates the first transmission period and the second row indicate the second transmission period. Where S_1 is sent from the first antenna and S_2 from the second antenna in the first transmission period. Whereas $-s_2^*$is sent from the first antenna and $s_1^*$from the second antenna in the second transmission period. The two rows and columns of S matrix are orthogonal to each other.The channel experienced between each transmit and receive antenna is randomly varying in time. However, the channel is assumed to remain constant over two time slots. The channels h_1 and h_2 are assumed to be known only at the receiver.

A block diagram of the Alamouti space-time decoder is shown in figure 5.2.2

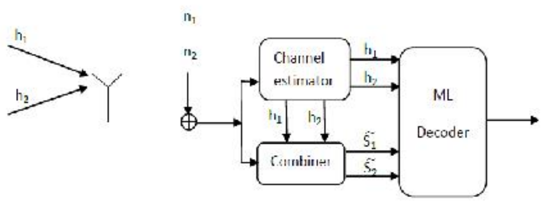

Figure5.2.2: Block diagram of Space time decoder

In the decoder, the received signal is fed to the channel estimator. The estimated coefficients of the channel together with the combiner are given as the input to the maximum likelihood detector. The detected signal is then fed to the demodulator. The demodulator gives the original information which it transmitted [3].

In the first time slot, the received signal is

$$Y_1 = h_1 s_1 + h_2 s_2 + n_1 \qquad (1)$$

$$Y_1 = [h_1 \;\; h_2] \begin{bmatrix} s_1 \\ s_2 \end{bmatrix} + n_1 \qquad (2)$$

In the second time slot, the received signal is

$Y_2 = -h_1 s_2^* + h_2 s_1^* + n_2$ (3)

$Y_2 = [h_1 \;\; h_2] \begin{bmatrix} -s_2^* \\ s_1^* \end{bmatrix} + n_2$ (4)

Where Y_1 & Y_2 are the received symbols on first and second time slot respectively. N_i is the AWGN noise in the i^{th} time slot where i = 1, 2. S_1& S_2 is the modulated signal from transmit antenna 1 & 2 respectively. h_1 & h_2 are channel coefficients between two transmit antennas.

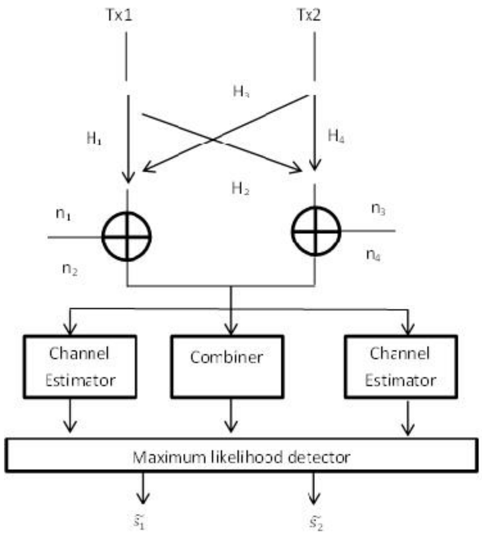

Figure5.2.3: Space-time block code scheme with two transmit and two receive antennas.

Above figure 5.2.3 shows STBC scheme of 2*2 antennas. The received signal at two receive antenna denoted by $r_1, r_2, r_3,$&r_4 for t and t+T respectively can be expressed by,

$r_1 = h_1 s_1 + h_2 s_2 + n_1$ (5)

$r_2 = -h_1 s_2^* + h_2 s_1^* + n_2$ (6)

$r_3 = h_3 s_1 + h_4 s_2 + n_3$ (7)

$r_4 = -h_3 s_2^* + h_4 s_1^* + n_4$ (8)

In the receiver, SM detection includes two steps, the first is identification of the index of transmit antenna, the second is symbol demodulation for this antenna[5]. The combiner in figure builds the following two combined signal that are sent to the maximum likelihood detector**.**

$\widetilde{s_1} = h_1^* r_1 + h_2 r_2^* + h_3^* r_3 + r_4^* h_4$ (9)

$\widetilde{s_2} = h_2^* r_1 - r_2^* h_1 + h_4^* r_3 - r_4^* h_3$ (10)

VI. STBC-SM

STBC-SM is a system which merges Space Time Block Code STBC and Spatial Modulation (SM).In this scheme, the transmitted data is dependent on the space, time and antenna indices. STBC-SM takes the benefits of this combination to attain high spectral efficiency which is realized using antenna indices to rely information.Low complexity maximum likelihood (ML) decoder is used in this scheme which gains from the orthogonality of the STBC code.By using space time block code there is no expansion in bandwidth. In the STBC-SM scheme, the transmitted symbols or bits are enlargednot only to the space and time domains but also to the spatial (antenna) domain; therefore both core STBC and antenna indices carry information. The proposed scheme is optimized by deriving its diversity and coding gains to exploit the diversity advantage of

STBC. Hereby band efficiencies of the system are increased. STBC-SM allows the system to have more reliableperformance in a fading environment and good performance with minimal decoding complexity. It can accomplish maximum diversity gain and receiver gain that use only linear processing to recover transmitted data.

VII. RESULTS

Alamouti space-time code is an orthogonal scheme that can achieve the full transmit diversity with two transmit antenna and two receive antenna. In this section, we present simulation result for the STBC-BPSK, QPSK & QAM modulation system with two transmit two receive antenna under Rayleigh fading channel. Also simulation results for the STBC-SM BPSK, QPSK & 16-QAM modulation are given. Finally the BER for various modulation schemes are compared.

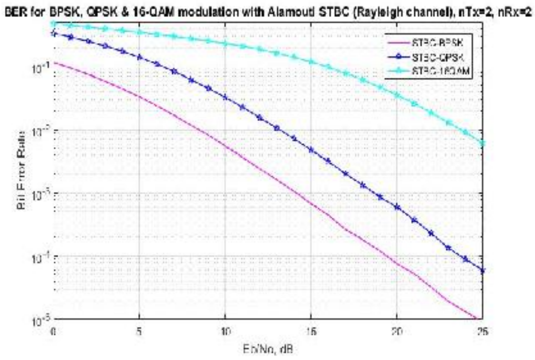

Figure 7.1: BER for BPSK, QPSK & 16-QAM modulation with Alamouti STBC

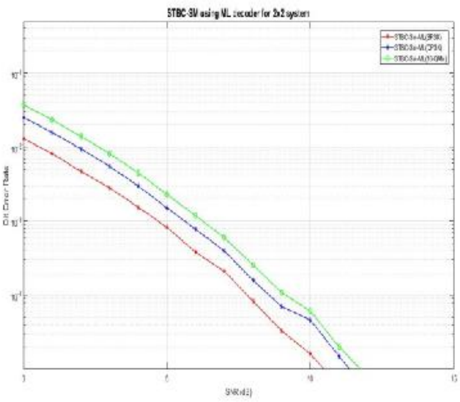

Figure 7.2: BER for BPSK, QPSK & 16-QAM modulation with STBC-SM

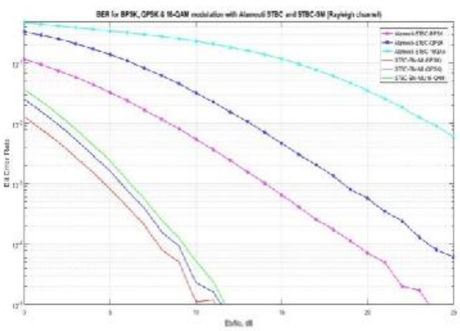

Figure 7.3: BER for BPSK, QPSK & 16-QAM modulation with Alamouti STBC & STBC-SM

Table 1: SNR values for different BER for Alamouti STBC

Modulation	No.of Tx:Rx	SNR (dB) for BER 10^{-4}	SNR (dB) for BER 10^{-3}	SNR (dB) For BER 10^{-2}
BPSK	2:2	18	13	8
QPSK	2:2	23	18	13
16-QAM	2:2	25	25	24

Table 2: SNR values for different BER for STBC-SM

Modulation	No.of Tx:Rx	SNR (dB) for BER 10^{-4}	SNR (dB) for BER 10^{-3}	SNR (dB) For BER 10^{-2}
BPSK	2:2	7	4	2
QPSK	2:2	8	4	3
16-QAM	2:2	9	6	3

From the above table, Space-time block codes using BPSK, QPSK, and 16-QAM modulation techniques showed optimal results in terms of bit-error-rate. The performance of space-time block codes with BPSK modulation is more desirable than the performance of space-time block codes with QPSK modulation by approximately 5 db. The performance of space-time block codes with QPSK modulation is better than the performance of space-time block codes with 16-QAM modulation by approximately 5~6 db. The performance of STBC-SM with BPSK modulation is better than the performance of STBC-SM with QPSK modulation by approximately 1-2 db. The performance of STBC-SM with QPSK modulation is better than the performance of STBC-SM modulation by approximately 1-2 db. This shows that STBC-SM give better performance than Alamouti STBC scheme.

VIII. CONCLUSION

In this paper, we have implemented a novel space time block code with spatial modulation as an alternative to existing techniques such as SM and V-BLAST[vertical Bell laboratories layered space time] which is detection algorithm to the receipt of multi antenna MIMO system.Alamouti scheme and space-time block codes encoding, decoding and performances were covered and explained in details. New transmission scheme i.e. employs both APM techniques & antenna indices to convey information & exploits the transmit diversity potential of MIMO channel.We conclude that the STBC-SM scheme can be useful for high-rate, low complexity, emerging wireless communication systems such as LTE and WiMAX.

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