International Journal of Engineering and Technical Research (IJETR)
ISSN: 2321-0869, Volume-1, Issue-7, September 2013

BER PERFORMANCE OF STBC ENCODED MIMO SYSTEMS

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Abstract— **In this paper the BER (bit error rate) performance of MIMO system. MIMO uses multiple transmitting antennas, multiple receiving antennas and the space time block codes to provide diversity. MIMO transmits signal encoded by space time block encoder through different transmitting antennas. These signals arrive at the receiver at slightly different times. Spatially separated multiple receiving antennas are used to provide diversity reception to combat the effect of fading in the channel. This paper presents a detailed study of diversity coding for MIMO systems. Finally, these STBC techniques are implemented in MATLAB and Simulation results displays the BER performance of MIMO system with varying number of transmitting antennas.**

Index Terms— **BPSK,QAM,MIMO,ML**

I. INTRODUCTION

In a wireless communication system, the transmitter sends the signal to receiver through the wireless channel. Channel may consist of reflectors which will lead to multi path propagation means the multiple copies of transmitting signal arrives at receiver after reflecting from the objects present in the channel. It causes the constructive or destructive interference. To combat the effect of interference or fading Multiple-Input Multiple-Output System is used. The other advantages of MIMO systems are Higher data rates with limited bandwidth and power resources, increased capacity, increased spectral efficiency(efficiently use of a limited frequency spectrum), faster speeds, more simultaneous users, less signal fading and dead spots, better resistance to interference and increased range (1).

Diversity can be achieved by providing a copy of the transmitted signal over frequency, time and space. Another scheme STBC is implemented to achieve full rate and full diversity. STBC involves block encoding an incoming stream of data and simultaneously transmitting the symbols over N_t transmit antenna elements [2].

Alamouti proposed this transmit diversity technique using two transmit antennas, whose key advantage was the employment of low complexity use of multiple symbols [2]. Tarokh et al. [3] extended Alamouti’s code to a generalized complex orthogonal design for Nt> 2. These codes achieve the maximum possible transmission rate for any number of transmit antennas using any arbitrary real constellation.

Manuscript received September 07, 2013.

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The main goal of this paper is to design the Multiple-input Multiple-Output (MIMO) systems to reduce fading and increase diversity gain. Channel estimation technique is used with the maximum likelihood decoder at the receiver end and the MSE of the channel is calculated. Multi-user MIMO systems can significantly improve system throughput via transceiver signal processing if the number of transmit antennas is much larger than the number of receive antennas. We shall consider the case of the simple Alamouti’s space-time block code as it is the only scheme which can provide full rate and full diversity for any signal constellations.

The rest of the paper is organized as follows. In Section 2, the introduction of MIMO system model is provided, Section 3 gives the different STBC techniques, Section 4 gives the Channel Estimation & Detection algorithm and Section 5 gives the Simulation Results of MIMO system with different number of transmitting antennas and effect of different modulation formats on the performance of the purposed technique under Rayleigh fading environment.

II. MODEL OF MIMO SYSTEM

The Model of the MIMO system is shown in fig 1. Multiple-In Multiple-Out (MIMO) is based on both transmit and receive diversity. With N_t transmission antennas and N_r receiver antennas there are N_tN_r branches

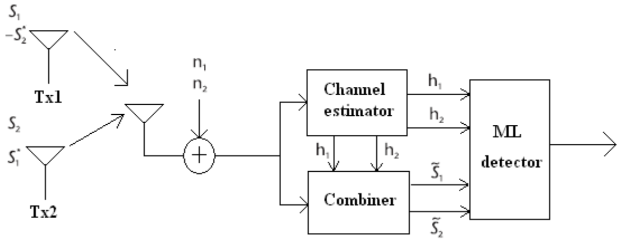


fig 1.Basic model of MIMO SYSTEM

The standard received signal vector can be calculated as

$$r=Sh+n$$

Where the S is the transmitted symbol, n is the noise and h is the MIMO channel matrix can be represented by a $N_t \times Nr$ matrix.

III. SPACE TIME BLOCK CODE TECHNIQUE

The very first and well known STBC is the Alamouti Code, which is a complex orthogonal space time code specialized for two transmit antenna.

The Alamouti space-time encoder pick up two symbols s1 and s2 from an arbitrary constellation and the two symbols are transmitted in two consecutive time slot as shown in figure 1. In the first time slot, s1 is transmitted from the first antenna while s2 is transmitted from second antenna. Consecutively in second time slot, -s2* is transmitted from first antenna while s1* is transmitted from second antenna. The key concept of the Alamouti STC scheme is the orthogonal design of the transmit sequences.

The inner product of the sequences x1 and x2 is given as :
x1*x2=s1s2*-s1s2*=0 (1)
The transmitted code matrix has the following property:

$$X \cdot X^H = \begin{bmatrix} |s_1|^2 + |s_2|^2 & 0 \\ 0 & |s_1|^2 + |s_2|^2 \end{bmatrix} \quad (2)$$

Maximum likelihood signal detection for Alamouti space time coding scheme. Assume two channel gains ,$h_1(t)$ and $h_2(t)$ are time invariant over two consecutive symbol periods,

$$h_1(t) = h_1(t+T) = h_1 = |h_1|e^{j\theta_1}$$

$$h_2(t) = h_2(t+T) = h_2 = |h_2|e^{j\theta_2} \quad (3)$$

where $|h_i|$ and θ_k k=1,2 are the amplitude gain and phase shift from the path from transmit antenna k to the receiver antenna and T is the symbol duration .

The received signal in the first time slot is given as :

$$r(t) = r_1 = h_1 s_1 + h_2 s_2 + \eta_1 \quad (4)$$

and in second time slot, the received signal is given as:

$$r(t) = r_2 = -h_1 s_2^* + h_2 s_1^* + \eta_2 \quad (5)$$

Where η1 and η2 are the complex white noise with zero mean and variance σ2 for the first time slot and second time slot, respectively. Assume that the receiver is coherent and optimal. Taking the complex conjugation of the second received signal .The estimates for channel ,are provided by the channel estimator. Assume that the channel gains ,h1 and h2 are exactly known to the receiver. Transmit symbols are now two unknown variables in the matrix. Multiplying both sides of equation by the Hermitian Transpose of the channel matrix.

Then the attempt to recover s1 and s2 can be given by the following linear combination:

$$\tilde{S} = \begin{bmatrix} h_1 & h_2 \\ h_2^* & -h_1^* \end{bmatrix}^H \begin{bmatrix} r_1 \\ r_2^* \end{bmatrix} = \begin{bmatrix} \sum_{k=1}^{M} |h_k|^2 s_1 + h_1^*\eta_1 + h_2\eta_2^* \\ \sum_{k=1}^{M} |h_k|^2 s_2 + h_2^*\eta_1 - h_1\eta_2^* \end{bmatrix} \quad (6)$$

Antenna interference does not exist anymore, the unwanted symbol s_2 dropped out of r_1 while the unwanted symbol s_1 dropped out of r_2.These is the complex orthogonality of the Alamouti code.

The decision variable vector $\tilde{S}$ with s mean and $\sigma^2 / \sum_{k=1}^{M} h_k$ variance is sent to the ML detector.

If the average power of the transmitted symbols is $E[|s_n|^2]$, the receiver SNR in each sub channel is given as :

$$\gamma = \sum_{K=1}^{M} h_k \frac{E[|s_n|^2]}{2\sigma^2} \quad (7)$$

The basic operation of OSTBC is shown in fig. 1 where the scheme can achieve full transmit diversity up to M order with M transmit antennas while allowing the use of a very simple ML decoding algorithm and linear combining at receiver. MISO STBC is more practical and promising to be implemented in WSNs due to a simpler decoding algorithm which leads to lower processing energy at receiver.

The Cooperative STBC transmit diversity system a source sensor communicates with a target sensor over a number of relaying sensors by utilizing distributed but cooperative low-complexity space-time encoding techniques, thereby achieving highly robust communication links. Each relaying stage is hence comprised of a given number of cooperating sensor nodes, which may or may not exchange additional data**.** The Cooperative STBC transmit diversity system M transmit node and 1 destination is shown in below fig.2

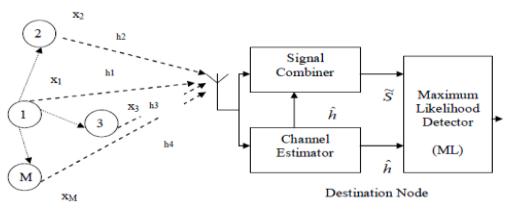


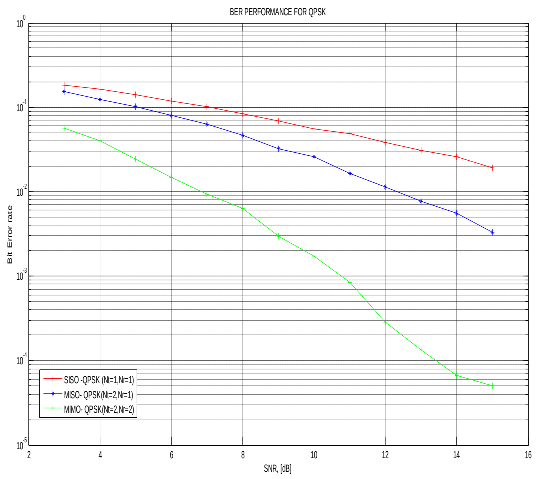
fig.2 .A Cooperative STBC transmit Diversity system with M transmit node and 1 destination.

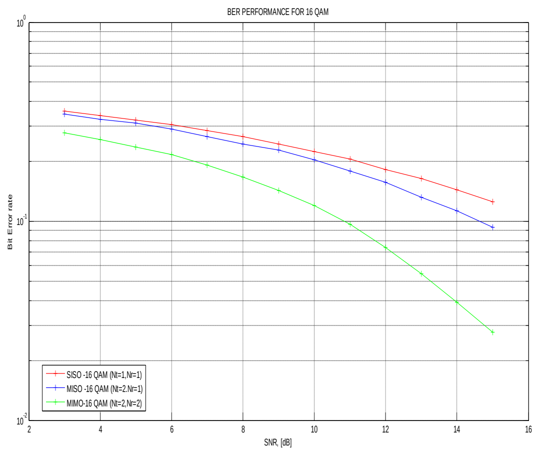
IV. CHANNEL ESTIMATION

The channel fading coefficients has been estimated by inserting pilot sequences in the transmitted signals. In general, with N_t transmitting antennas need N_t different pilot sequences P_1, P_2… P_{Nt}. These pilot sequences have been transmitted as a preamble of symbols.

V. SIMULATED RESULTS

Simulations are done in MATLAB , The results for BER (bit error rate) performances are presented for SISO,MISO,and MIMO antenna system using QPSK and 16 QAM modulation scheme for different antennas at the transmitter side are shown below.





VI. Conclusion

This paper presents the block codes schemes with 1and 2, transmitting antennas. Simulation results were shown. It has been concluded that Alamouti scheme provides full diversity without need of feedback from the receiver to the transmitter. Hence, the use of Alamouti scheme at the transmitter can result in the use of low complexity decoder ,like maximum likelihood decoder at the receiver. It was observed that Space-time block codes with larger number of transmit antennas always give better performance than space-time block codes with lower number of transmit antennas due to larger number of transmit antennas that has larger transmission matrices which means transmitting more data.

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