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Performance Analysis of MIMO-STBC System for M-PSK Techniques using Hamming Coding

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Abstract : Space Time Block Code (STBC) is a powerful transmit diversity scheme for Multiple-Input and Multiple-Output (MIMO) antenna systems. STBC is used in MIMO Systems to improve the performance by maximizing the diversity gain. In this paper, performance of MIMO-STBC for different modulation techniques such as BPSK, QPSK, 8-PSK and 16-PSK using Hamming Coding is analysed on the basis of BER and SNR.

Keywords: Multiple-input Multiple-output (MIMO), Space Time Block Code (STBC), Alamouti, Bit Error Rate (BER), Hamming Coding.

I. INTRODUCTION

In wireless communication, there is a demand for voice, data and multimedia services. To support these services large capacity channels are required. In wireless communication, the signal from transmitter is reached form various paths [1]. Each will have different phase shift, time delay and attenuation which results in variation in signal strength. This is known as multipath fading. Multiple copies of transmitted signal is received at the receiver which degrades the system performance [2]. The basic idea is that if different copies of same signal are available then there is a high probability that at least one of them is of good quality [3]. Diversity techniques are used to improve the performance in fading channel. Instead of transmitting over single channel, different copies of signal are transmitted over different channels. By using multiple antennas both at transmitter and receiver end, diversity can be obtained. This system is referred to as multiple-input multiple-output (MIMO). These systems got higher consideration in Alamouti STBC where data is coded through space and time [4]. MIMO is based on both transmit and receive diversity. The core idea in MIMO systems are space-time signal processing in which time is complemented with the spatial dimension inherent in the use of multiple spatially distributed antennas [5]. In MIMO systems, a transmitter sends multiple copies of data through multiple transmit antennas. Transmission and reception is done over space (antennas) and time (successive symbols) [6]. The system is described with the channel model with the help of equation given below:

$$y=Hx+n$$

where y and x are receive and transmit vectors, respectively. H is channel matrix and n is noise vector [7].

The idea behind MIMO is that the transmit antennas and the receive antennas are connected and combined in such a way that BER or the data rate for each user is improved [8]. These systems enhance the channel capacity to achieve a high data rate transmission [9]. The overall effect of MIMO systems can be summarized in terms of reduction of bit error rate and increase in system capacity [10]. This paper describes performance analyses of MIMO-STBC for m-PSK using hamming coding. This technique is capable of providing better data rates and significant reduction in bit error rate.

II. SPACE TIME BLOCK CODE

Space time block code is presented by the Alamouti [11]. He suggested a space time code for two transmit antennas, which provides a diversity gain and has a simple decoder [12]. This scheme provides transmit and receive diversity to the MIMO systems. It deals with block of data and provides only diversity gain not coding gain. Recently, multiple antenna

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techniques have been studied for high data rate transmission and increased transmission efficiency [13].

A simplified block diagram using Alamouti is described in fig.1. This scheme is defined by following three functions:

1. Encoding and decoding transmission sequence information symbols at the transmitter.
2. Combining signals with noise at the receiver.
3. Maximum likelihood detection.

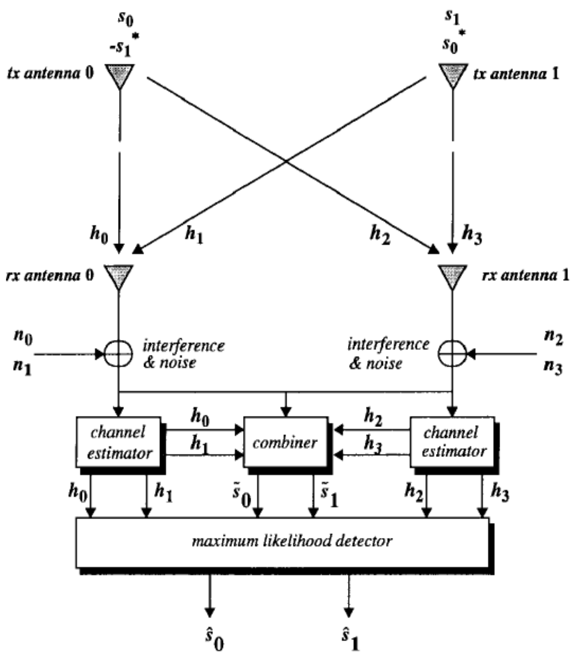

Fig.1. Simplified Alamouti space time coding (STC) for 2x2 MIMO systems [11].

At a given time period, two signals are simultaneously transmitted from two antennas. At time t, antenna 0 will transmit the signal S_0 and antenna 1 will transmit the signal S_1. At time (t+T), antenna 0 will transmit the signal $(-S_1^*)$ and antenna 1 will transmit the signal S_0^* where * is complex conjugate operation. The sequence is shown below:

Table 1. Encoding and transmission sequence for Alamouti STBC scheme [11]

Time Slots	Antenna 0	Antenna 1
time t	S_0	S_1
time (t+T)	$(-S_1^*)$	S_0^*

The received vectors can be expressed as,

$r_0 = h_0 S_0 + h_1 S_1 + n_0$ (1)

$r_1 = h_0 (-S_1^*) + h_1 S_0^* + n_1$ (2)

$r_2 = h_2 S_0 + h_3 S_1 + n_2$ (3)

$r_3 = h_2 (-S_1^*) + h_3 S_0^* + n_3$ (4)

where n_0, n_1, n_2, n_3 are thermal noise and interference, r_0, r_1, r_2, r_3 denote the received vectors and S_0 and S_1 are modulated symbols.

The combiner will combine the two signals and then are sent to the maximum likelihood detector and expressed as,

$\tilde{S}_0 = h_0^* r_0 + h_1 r_1^* + h_2^* r_2 + h_3 r_3^*$ (5)

$\tilde{S}_1 = h_1^* r_0 - h_0 r_1^* + h_3^* r_2 - h_2 r_3^*$ (6)

III. SYSTEM MODEL

The system model is shown in fig.2. Source will provide the input data to the system. The input can include data bits, pictures, video and voice. Here data bits are transmitted through Rayleigh Fading channel. The channel encoder adds the redundant bits to the information pattern for error detection and correction [14]. In this system, hamming coding is used as channel coding technique. Hamming introduced the (7,4) code. It encodes 4 data bits into 7 bits by adding three parity bits. Hamming (7,4) can detect and correct single-bit errors [15]. The modulator will modulate the input data so that it can reach the receiver. The incoming data streams are modulated by using M-PSK techniques. There are four modulation techniques that are BPSK, QPSK, 8-PSK, and 16-PSK. The modulated signal is then transmitted through different channels using multiple transmit antennas at transmitter side. Multiple versions of data will be received at the receiver using multiple receiver antennas. Space Time Block Coding (STBC) based on Alamouti scheme based on both transmit and receive diversity [11]. S_0 and S_1 are the actual transmitted signal. The signal is passed through Rayleigh fading channel. Noise is also added though the channels which lowers the performance of the signal.

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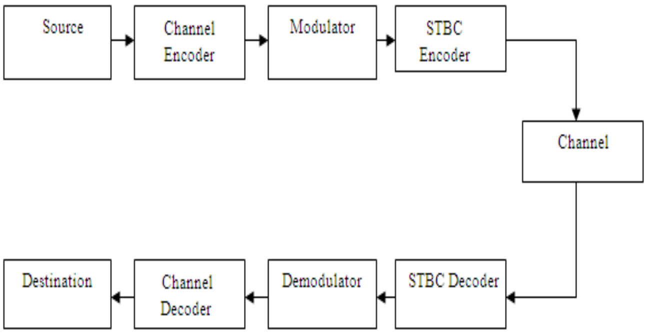

Fig.2. System Model [2]

In the STBC decoder received signals are combined by maximal ratio combining and detected by maximum likelihood detection. The demodulator will demodulate the signal to get the original signal. At the receiver, channel decoding is done using syndrome decoding. The channel decoder performs the opposite function to construct the estimation of information pattern.

IV. RESULTS & DISCUSSION

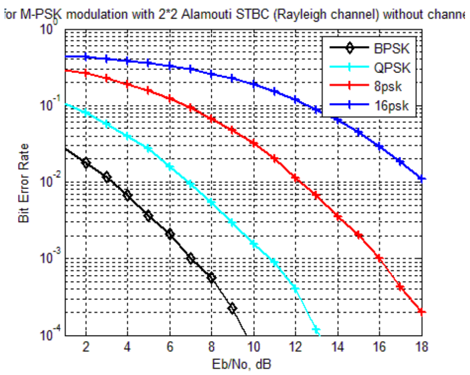

Fig.3. BER Plot of MIMO-STBC for BPSK, QPSK, 8-PSK, 16-PSK without Hamming Coding

Table 2. SNR required at BER $7*10^{-2}$ for M-PSK for 2*2 Alamouti Scheme without Hamming Coding

Sr. No.	Modulation Scheme	SNR(db)
1	BPSK	4
2	QPSK	7.9
3	8-PSK	13.2
4	16-PSK	Greater than 18

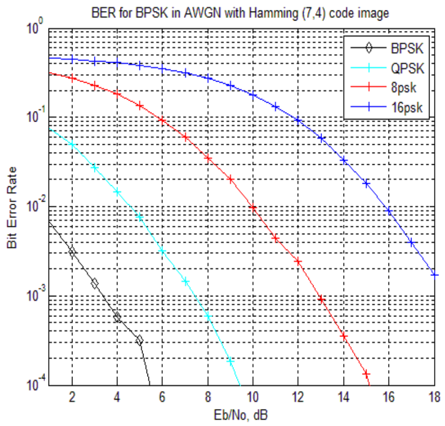

Fig.4 BER Plot of MIMO-STBC for BPSK, QPSK, 8-PSK, 16-PSK using Hamming Coding

In the simulation, the channel is assumed to be Rayleigh flat fading channel. The transmission employs different modulation techniques such as BPSK, QPSK, 8-PSK and 16-PSK. Maximum likelihood detection is done at the receiver for detection of signal. BPSK is more power efficient and needs less bandwidth. BPSK has less BER than the other techniques.

Table 3. SNR required at BER $7*10^{-2}$ for M-PSK for 2*2 Alamouti Scheme with Hamming Coding

Sr. No.	Modulation Scheme	SNR(db)
1	BPSK	1.8
2	QPSK	5.9
3	8-PSK	11.1
4	16-PSK	17

V.CONCLUSION

Space Time Block Codes with low order modulation always give low bit error rate as compared with Space Time Block Code with high order modulation. The result shows that Bit

Error Rate (BER) of STBC with 16-PSK modulation is less for high SNR and BER with BPSK is less for low SNR. Thus STBC with BPSK is more power efficient and require less bandwidth

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