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PERFORMANCE EVALUATION of MIMO SYSTEMS WITH VARYING NUMBER OF TRANSMITTING ANTENNAS

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Abstract: In this paper it evaluates 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 and MSE performance for two channels under Rayleigh fading environment.

Keywords: MIMO, STBC, BPSK, MSE

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. Billjana et al. [4] report on performance of quasi- orthogonal space-time block codes (QOSTBC) on measured MIMO channel using four transmit and four receive antennas. Seshadri and winters proposed signaling techniques for frequency division duplex to provide the diversity benefit to receiver with multiple transmitting antennas [5]. Capacity of multi antenna system is larger as compared to single antenna system. [6] - [10].

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.

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

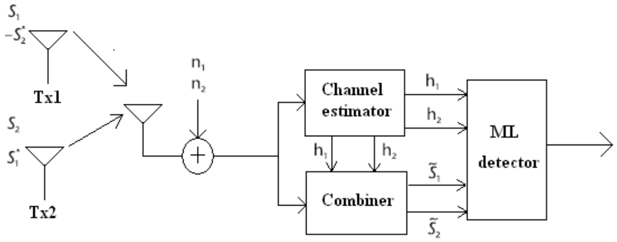

Fig.1. Model of MIMO system

The standard received signal vector can be calculated as [7]

$$r = Sh + n$$

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 CODING TECHNIQUES

Employing multiple antennas at the transmitter and receiver increases the capacity [7] but leads to increase in interference. This can be reduced by using space time block codes.

A. *Alamouti's STBC*

The STBC encoder takes a block of two modulated symbols s_1 and s_2 in each encoding operation and gives it to the transmit antennas according to the code matrix given in equation (1)

$$S = \begin{pmatrix} s_1 & -s_2^* \\ s_2 & s_1^* \end{pmatrix} \quad (1)$$

The first column represents the first transmission period and the second column the second transmission period. The first row corresponds to the symbols transmitted from first antenna and second row corresponds to the symbols transmitted from second antenna.

At the receiver the faded signals are corrupted by additive White Gaussian Noise (AWGN) process. Where r1 correspond to the symbols s1 and s2 sent from antennas 1 and 2 respectively at time t = t1 and r2 corresponds to the symbols – s2* and s1 sent from antennas 1 and 2 respectively at time t= t1 + T. n1 and n2 are the sample functions of an additive white Gaussian noise process. r1 and r2 can be given as

$$r_2 = -h_1 s_2^* + h_2 s_1^* + n_2 \quad (2)$$

$$r_1 = h_1 s_1 + h_2 s_2 + n_1 \quad (3)$$

The decoder consists of first estimating the channel gains for reliable decoding and a combiner that utilizes the estimated gains and the received data sequences to correctly decode the symbols. It has been assumed that the receiver is able to perfectly estimate the channel gains h_1 and h_2. The ML detector then calculates the decision metric.

B. *Orthogonal Space-Time Block Codes:*

With increasing transmitting antenna the N_t symbols have been transmitted simultaneously during the slot t from N_t transmit antennas

$$s_t = \left[s_t^1, s_t^2, \ldots\ldots, s_t^{n_t} \right]^T, 1 \le t \le N \quad (4)$$

The space-time codeword matrix with Nt transmit antennas and 1 receive antenna is given below

$$S = [s_1, s_2, \ldots\ldots, s_N] = \begin{pmatrix} s_1^1 & s_2^1 \ldots\ldots\ldots\ldots & s_N^1 \\ s_1^2 & s_2^2 \ldots\ldots\ldots\ldots & s_N^2 \\ . & . & \\ . & . & \\ . & . & \\ s_1^{n_t} & s_2^{n_t} \ldots\ldots\ldots\ldots & s_N^{n_t} \end{pmatrix} \quad (5)$$

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 using the Rayleigh fading channel. Figure 2 shows the BER performance of BPSK modulation scheme for different antennas at the transmitter side under Rayleigh fading environment for two channels. Figure 3 shows the MSE Performance of BPSK modulation scheme under Rayleigh fading environment for two channels. From figure 2 it has been observed that with increasing SNR, BER decreases. Using 4 transmitting and 1 receiving antennas gives lower BER as compared to using 2 transmitting and 3 transmitting antennas. From figure 3 it has been observed that the MSE in channel estimating for channel gain h_2 is less as compared to channel gain h_1. This can be interpreted due to large fading in channel 1 as compared to channel 2. It is also seen that MSE decreases with increasing SNR

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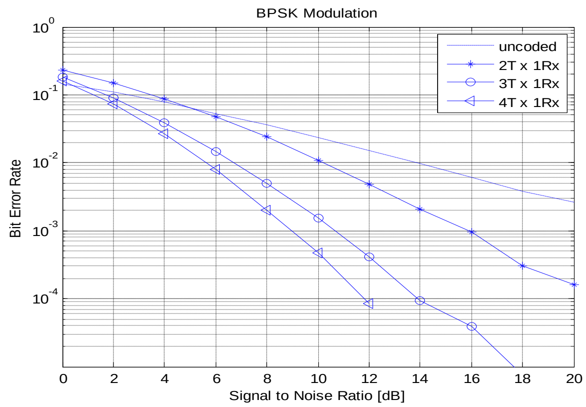

Fig.2. BER performance of BPSK modulation scheme for different antennas under Rayleigh fading environment

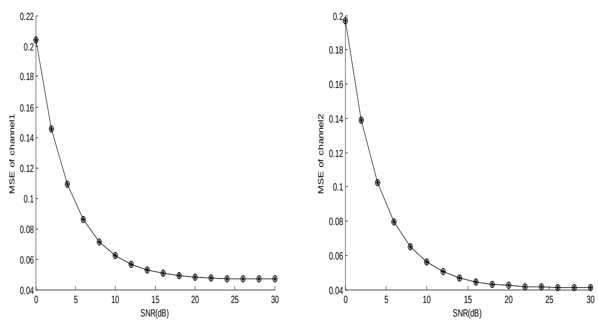

Fig.3. MSE Performance of BPSK modulation scheme under Rayleigh fading environment for two channels

VI. CONCLUSION

This paper presents the block codes schemes with 2, 3 and 4 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. From MSE performance of 2 channels, it can be concluded that lower the fading in the channel, better the channel estimation

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