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Simulation of MIMO Antenna Systems in Simulink

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ABSTRACT*:* MIMO system is an emerging technology in wireless communication. MIMO uses multiple transmitting antennas, multiple receiving antennas and the space time block codes to provide diversity. This paper simulates the MIMO system with different modulation techniques. The Simulink model of MIMO system is designed to evaluate the performance in terms of error ratio and MSE performance for two channels under Rayleigh fading environment. The Simulink is highly configurable, easily extensible, and can generate exhaustive performance and complexity measurements. This paper presents a detailed study of diversity coding for MIMO systems. Simulation results are presented which indicate that the Error ratio of system using BPSK modulation technique is decreasing more rapidly as compared to the system using QPSK modulation technique.

Keywords: MIMO, STBC, BPSK, MSE, ERROR RATIO

I. INTRODUCTION

MIMO systems use multiple antennas at both transmitter and receiver, so both transmit and receive diversity are applied to mitigate fading resulting from signal [1-2]. A scheme STBC (Space Time block Coding) is implemented to achieve full rate and full diversity. STBC involves block encoding an incoming stream of data and simultaneously transmitting the symbols over number of transmit antenna elements [3]. This technique was first proposed by Alamouti for M = 2 and N = 1, where M is the number of transmit antenna elements and N is the number of receive antenna elements. Alamouti space-time code is the simple transmit diversity scheme which improves the signal quality at the receiver on one side of the link by simple processing across two transmit antennas on the opposite side [3]. Hassibi [4] proposed a high rate coding scheme that can handle any configuration of transmitting and receiving antenna. The scheme sends the substreams of data over space and time. Zhu and Jaferkhani [5] proposed a differential modulation scheme based on QOSTBC when both transmitter and receiver do not have the channel state information. Tarokh [6] proposed a detection algorithm for the Alamouti's scheme dispensing with channel estimation.The algorithm has to estimate the channel during the very first time instant using training symbols. The newdetection schemes require no channel state information ateither the transmitter or the receiver.

The main goal of this paper is todevelop a simulation platform for space-time block coding technique using Alamouti scheme at the transmitter and maximum likelihood decoder & channel estimator at the receiver and evaluate its performance in terms of MSE and error ratio using BPSK and QPSK modulation technique.

The rest of the paper is organized as follows. In section II, the MIMO system model is introduced, Section III gives the AlamoutiSTBC technique, Section IV presents the Simulink model, and the Simulation Results of MIMO system with different modulation formats on the performance of the purposed technique under Rayleigh fading environment is presented in Section V and Section VI concludes the paper

II. 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 [8]

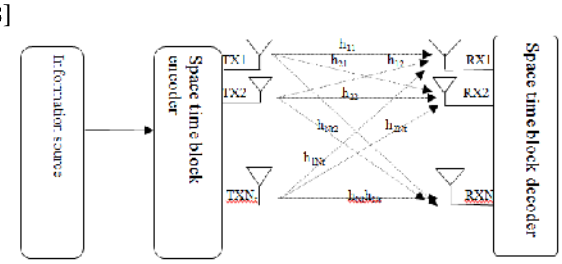

Fig.1. MIMO system model.

In space time coded MIMO system bit stream is mapped into symbol stream [x_i] where iis the antenna index. The symbol rate of space time coded system is given by equation (1)

R= N/ T symbols / channels use ...(1)

Where N is the no of symbols transmitted by a codeword over T symbol times

III. ALAMOUTI STBC

A Space time Code is developed by Alamouti [3]. The symbols z_1 and z_2 are encoded by the following matrix given by equation (2)

$$Q= \begin{bmatrix} z_1 & z \\ -z_2^{*} & z \end{bmatrix} \quad \text{... (2)}$$

At a given symbol period, two signals are simultaneously transmitted from the two antennas. The signal transmitted from antenna 1 is denoted by z_1 and from antenna 2 by z_2. During the next symbol period signal $-z_2$* is transmitted from antenna 1, and signal z_1* is transmitted from antenna 2 as shown in equation (2) [3][6].

IV. SIMULINK SIMULATION

In order to demonstrate the MIMO communicationssystem principle, a SIMULINK model wasdeveloped. This simulation focuses on implementation of Diversity technique (Alamouti STBC) after modulating the input streams using BPSKand QPSK modulationtechniques at transmitter end andimplementing the channel estimation and maximum likelihood decoder at the receiver end. Assume a 2 X 1system which has two transmitting antennas and one receiving antenna, the exact steps taken for the simulation are listed below

(*i*) First a random bit stream has been generated.
(*ii*) Pilot bits are added for channel gain estimation from each transmit antenna to the receiver antenna.
(*iii*) Then signal power level can be defined and using the encoding scheme the symbols are generated that are supposed to be transmitted [3].
(*iv*) The encoded symbols can be transmitted through multipath faded channel. Here channel can be assumed to be flat faded and channel distortion can be assumed to be multipath.
(*v*) Then AWGN can be added in the system which has been generated using normally distributed.
(*vi*) At the receiver end channel is estimatedusing minimum mean square error estimation [7] and the symbols were detected using Maximum likelihood decoder [6].
(*vii*) Finally errors were determined
(*viii*) Also the mean square error is calculated i.e.the average of the square of errors between estimated channel gain and actual channel gain between transmitter and receiver.
(xi) The system performance has then measured at different values of SNR and for different modulation schemes.
10,000 symbols have been generated for each simulation and then the BER v/s SNR curves are plotted. Then comparison has been done between different modulation schemes (BPSK and QPSK) and also evaluates the performance comparison of both modulations under Rayleigh fading environment.

V. ERROR PERFORMANCE RESULTS

Fig. 2 shows the Error ratio performance of BPSK and QPSK modulation schemes for 2 transmitting antennas and 1 receiving antenna of Alamouti scheme of space-time block codes under Rayleigh fading environment. Error ratio of system using BPSK modulation technique is decreasing more rapidly as compared to the system using QPSK modulation technique and also error ratio decreases with increasing SNR.

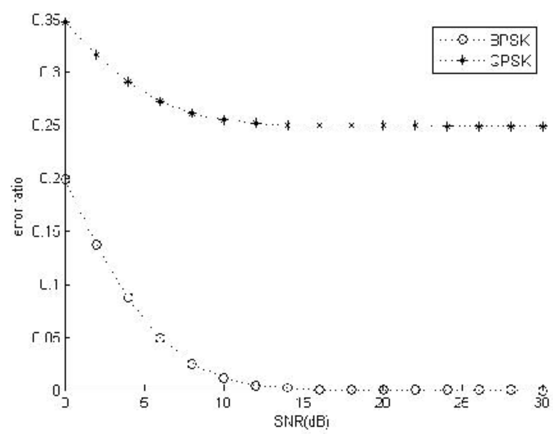

Fig. 2. Error ratio of BPSK and QPSK modulation scheme for 2 transmitting antennas and 1 receiving antenna under Rayleigh fading environment.

From Fig 2 it is clear that with increase in the signal to noise ratio from 0 to 35, the Error ratio decreases from 0.35 to 0.250 with using QPSK modulation technique and in BPSK modulation technique with increase in the signal to noise ratio from 0 to 35, the Error ratio decreases from 0.2 to 0.

Fig. 3 shows the MSE Performance of BPSK modulation scheme under Rayleigh fading environment for channel 1. Withincrease inSignal to Noise Ratio, the MSE decreases. Figure 3 also shows thatwith increase in Signal to noise ratio (SNR) from 0 to 30, the Mean square error (MSE) decreases from 0.21 to 0.047.

Fig. 4 shows the MSE Performance of BPSK modulation scheme under Rayleigh fading environment for channel 2.

From Figure 3, it has been shown that MSE decreases with increasing SNR.

Fig. 4 also shows thatwith increase in Signal to noise ratio (SNR) from 0 to 30, the Mean square error (MSE) decreases from 0.188 to 0.

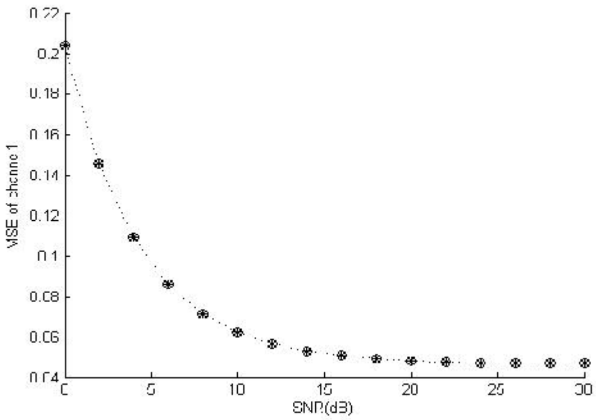

Fig. 3. MSE Performance of BPSK Modulation scheme under Rayleigh fading environment for channel 1.

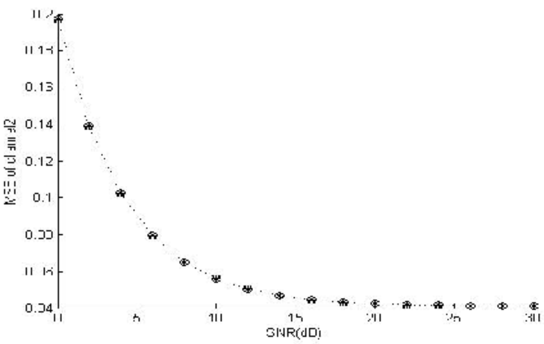

Fig. 4. MSE Performance of BPSK modulation scheme under Rayleigh fading environment.

By comparing figure 3 and figure 4 it has been shown that channel 2 has lower MSE than MSE of channel 1. So Channel 2 is better than channel1. It can be concluded that the MSE in channel estimating for channel gain h_2 is less as compared to channel gain h_1.This is due to the large fading in channel 1 as compared to channel 2. As the fading will be less, better will be estimation of channel.

VI. CONCLUSION

The Simulink model of MIMO system has been presented in this paper. Error ratio is calculated using different modulation techniques (BPSK, QPSK) and the results are compared with each other. Mean square error is calculated between actual channel gain and estimated channel gain from transmitter to receiver.

From the simulation results one can show that 1) withincrease in Signal to noise ratio, Error ratio and MSE decreases. 2) As the fading will be lower, the better will be the channel estimation.

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