International Journal of Innovative Technology and Exploring Engineering (IJITEE)
ISSN: 2278-3075 (Online), Volume-3 Issue-1, June 2013

Study of Transmission Characteristics of MIMO System for Different Modulation Techniques

Narendra M R

Abstract— ***The performance of 2X2 Multiple Input multiple Output (MIMO) antenna systems has been analyzed by determining the transmit diversity using Alamouti Space Time Coding (STBC) techniques. For the BPSK and QPSK modulation technique transmission characteristics are determined. Adaptive White Gaussian Noise (AWGN) has been used presuming flat fading Rayleigh channel. On receiver side, linear equalization techniques such as Zero Forcing (ZF) and Maximum Likelihood Detector (MLD) were employed for computing BER. It is found that for 5 dB Eb/No, the BER values of BPSK using ZF Equalizer 0.0687, BPSK using MLD Equalizer 0.0151, QPSK using ZF Equalizer 0.0070, QPSK using MLD Equalizer 1 is obtained. But BER value for BPSK Modulation with 2X2 Alamouti STBC and the BER value for QPSK Modulation with same 2X2 Alamouti STBC are obtained respectively as 0.0038 and 0.0034. The results indicate that the STBC multiplexing schemes show an overall improvement of ~67.95 dB between BPSK and QPSK modulation for the same 5 dB Eb/No value. The STBC multiplexing for digital transmission shows significant improvement in BER performance with higher levels of digital modulation. MATLAB tool is used for simulation and results are discussed in the paper.***

Index Terms— ***Multiple Input Multiple Output (MIMO), Space Time Block Code (STBC) Phase Shift Keying (PSK)***

I. INTRODUCTION

A unique characteristic in a wireless channel(mobile radio channel) is a multipath fading environment. The signal at the receiver end contains not only the transmitted radio wave, it also includes a large number of reflected radio waves arrived at different times. Delay in the received signal is the result of reflections from the obstacles such as buildings, mountains, vehicles, hills or trees. These reflected delayed waves interfere with direct waves and cause Inter Symbol Interference (ISI) which causes significant degradation of network performance. MIMO technology has attracted attention in wireless communications, because of better data throughput and link range without additional bandwidth or transmit power . MIMO achieves this by higher spectral efficiency and link reliability or diversity. MIMO is an important part of modern wireless communication standards such as IEEE 802.11n (Wi-Fi), 4G, 3GPP Long Term Evolution and WIMAX [4, 5]. The performance of the two transmit two receive antenna case resulting in a 2X2 MIMO channel have been studied. It is assumed that the transmission channel is a flat fading Rayleigh multipath channel and the modulation is BPSK and QPSK includes the Alamouti Space Time Block Coding (STBC) schemes [3]. Diversity coding techniques are used when there is no channel knowledge at the transmitter. A single stream of signal is transmitted in diversity method but the signal is coded using techniques called Space Time Code. The signal is emitted from each of the transmit antennas using certain principles of full or near orthogonal coding. Diversity exploits the independent fading in the multiple antenna links to enhance signal diversity Space Time Code. Redundant data sent over time space domains (antennas) and the receive SNR increases for different digital modulation schemes. Since wireless technologies become a very high demand nowadays, STBC has been chosen to be a subject study for different digital modulation schemes [6]. The present study involves four procedures namely modeling, simulations of the STBC transmission system, digital transmission system and computation and comparison of BER. We will study and identify multiple input multiple output (MIMO) technology that gives best bit error rate (BER) performance for different digital modulation Schemes(BPSK,QPSK) using MATLAB simulation.

Manuscript published on 30 June 2013.
***Correspondence Author(s)**
Narendra M R, Department of Electronics and Communication, Canara Engineering College Mangalore, India.

II. SPACE TIME BLOCK CODE

In wireless communication Space-Time Coding technique is used to transmit multiple copies of a data stream across a number of antennas and to exploit the various received versions of the data to improve the reliability of data-transfer and also additionally improve the performance and make Spatial Diversity useable. In this technique copy of the signal is transmitted from another antenna but also at another time. Because transmitted signal must traverse in no line of sight environment such as scattering, reflection, refraction and so on and may then be further corrupted by thermal noise in the receiver means that some of the received copies of the data will be better than other received copies. This results in a higher chance of being able to use one or more of the received copies to correctly decode the received signal. Space–time coding combines all the copies of the received signal in an optimal way to extract as much information from each of them as possible. Figure1 shows the signals s1 and s2 are multiplexed in two data chains. Then signal replication is added to create the Alamouti Space-Time Block Code [1]. The receiver sees a combination of what was transmitted from both transmit antennas. MIMO system attempt to overcome this by using various coding schemes that define what signals should be transmitted and at what times, to make it possible to recover the original signals from the jumbled version that is received. These coding schemes are known as "Space-Time" codes because they define a code across space (antennas) and time (symbols).

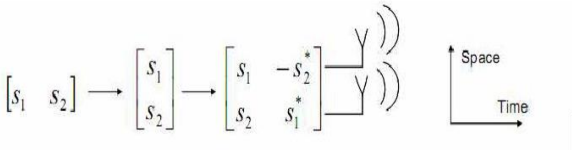

Fig.1. Almouti code for two transmitter antennas

Published By:
Blue Eyes Intelligence Engineering and Sciences Publication (BEIESP)

Here, receiver diversity is used by considering the ZF equalizer which is intended to remove the effect of channel from the received signal, in particular the Inter Symbol Interference (ISI), when the channel is noiseless. However when the channel is noisy, the ZF equalizer will amplify the noise greatly at frequencies f where the channel response is H (j2πf) has a small magnitude in the attempt to invert the channel completely. A more balanced linear equalizer is the MLD equalizer does not usually eliminate ISI completely but instead minimizes the total power of the noise and ISI components in the output. MLD equalizer can avoid Inter Block Interference (IBI) [7]. By reducing the number of redundant symbols in the transmitted signals, the spectral efficiency of the communication system with long channel dispersion can be greatly improved. The AWGN (Additive White Gaussian Noise) channel model is one in which the information is given a single impairment: a linear addition of wideband or white noise with a constant spectral density and a Gaussian distribution of noise samples. The model does not account for the phenomena of fading, frequency selectivity, interference, nonlinearity or dispersion. AWGN is commonly used to simulate background noise of the channel under study, in addition to multipath and interference [1, 2].

III. ALAMOUTI CODE FOR 2X2 MIMO SYSTEM

The Alamouti code is the first STBC that provides full diversity at full data rate for two transmit antennas

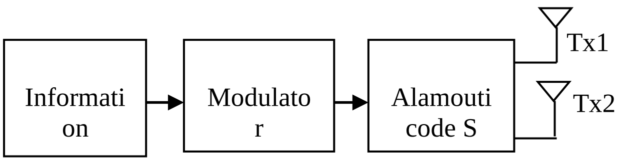

Fig.2. A block diagram of the Alamouti space-time encoder

The transmitter Tx1 transmits s1 = [s1 $-s_2^*$] and tramitter Tx2 transmits s2 = [s2 s_1^*]. A block diagram of the Alamouti space-time encoder is shown in Fig.2. The information bits are first modulated using an M-ary modulation scheme. The encoder takes the blockof two modulated symbols s1 and s2 in each encoding operation and hands it to the transmit antennas according to the code matrix

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

The first row represents the first transmission period and the second row the second transmission period. During the first transmission, the symbols s1 and s2 are transmitted simultaneously from antenna one and antenna two respectively. In the second transmission period, the symbol $-s_2^*$ is transmitted from antenna one and the symbol s_1^* from transmit antenna two. It is clear that the encoding is performed in both time (two transmission intervals) and space domain (across two transmit antennas). The two rows and columns of s are orthogonal to each other and the code matrix is orthogonal

$$\begin{aligned} \mathbf{SS}^H &= \begin{bmatrix} s_1 & s_2 \\ -s_2^* & s_1^* \end{bmatrix} \begin{bmatrix} s_1* & -s_2 \\ s_2^* & s_1 \end{bmatrix} \\ &= \begin{bmatrix} |s_1|^2+|s_2|^2 & 0 \\ 0 & |s_1|^2+|s_2|^2 \end{bmatrix} \\ &= (|s_1|^2+|s_2|^2)\mathbf{I}_2, \end{aligned}$$

where I2 is a (2 × 2) identity matrix. This property enables the receiver to detect s1 and s2 by a simple linear signal processing operation.

Let us look at the receiver side now. The received signal is of the form, r = hs+n

1st time slot

r1 = h1 S1 + h2 S2 + n1

r2 = h1 S1 + h2 S2 + n2

2nd time slot

r1 = - h1 S2* + h2 S1* + n1

r2 = - h1 S2* + h2 S1* + n2

IV. RESULTS AND DISCUSSION

In a 2×2 MIMO channel, probable usage of the available 2 transmit antennas can be as follows: Consider that we have a transmission sequence, for example {x1, x2, x3…..xn}. In normal transmission, we will be sending x1 in the first time slot, x2 in the second time slot, x3 in the third time slot and so on. But using STBC technique group the symbols into groups of two for 2 transmit antenna. Send x1 from the first antenna and x2 from second antenna in the first time slot. Send x3 and x4 from the first and second antenna in second time slot; send x5 and x6 in the third time slot and so on. We are grouping two symbols and sending them in one time slot, we need only n/2 time slots to complete the transmission. Using this technique data rate is doubled. This example gives the simple explanation of a probable MIMO transmission scheme with 2 transmit antennas and 2 receive antennas assuming channel is flat fading [2]. The simulation results for the performance of STBC for different digital modulation techniques BPSK and QPSK for AWGN channel are obtained using MATLAB. The BER values as function of SNR are determined for each modulation scheme for the purpose of comparing their relative performances. The Fig. 3, 4, 5 and 6 shows the bit-error-rate performances for BPSK modulation with 2X2 MIMO and ZF equalizer, BPSK Modulation with 2X2 MIMO and ML equalizer, QPSK Modulation with 2X2 MIMO and ZF equalizer and QPSK Modulation with 2X2 MIMO and ML equalizer respectively.

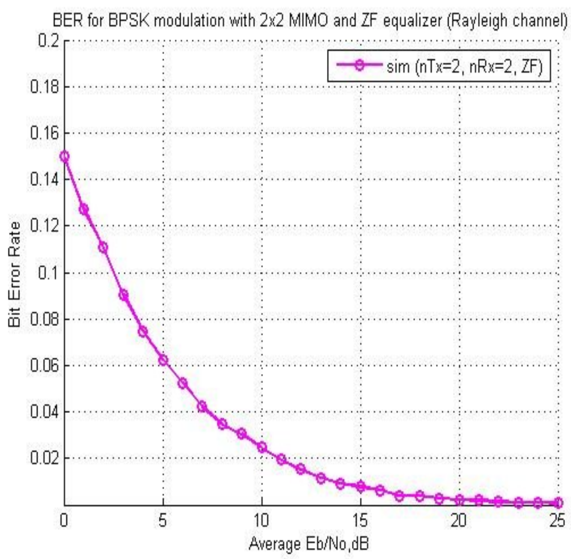

Fig.3. BER performance of BPSK Modulation for Rayleigh Fading and ZF equalizer

Published By:
Blue Eyes Intelligence Engineering and Sciences Publication (BEIESP)

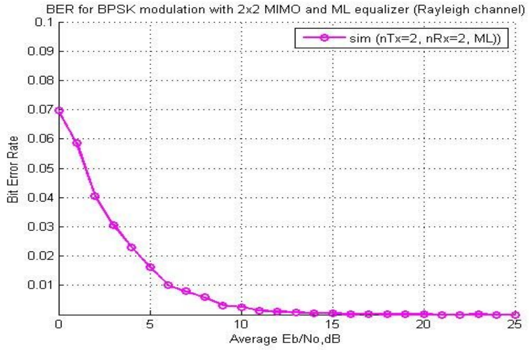

Fig.4. BER performance of BPSK Modulation for Rayleigh Fading and ML equalizer

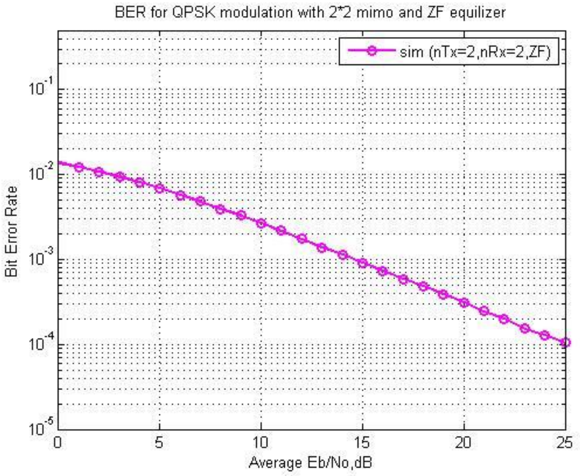

Fig.5. BER performance of QPSK Modulation for Rayleigh Fading and ZF Equalizer

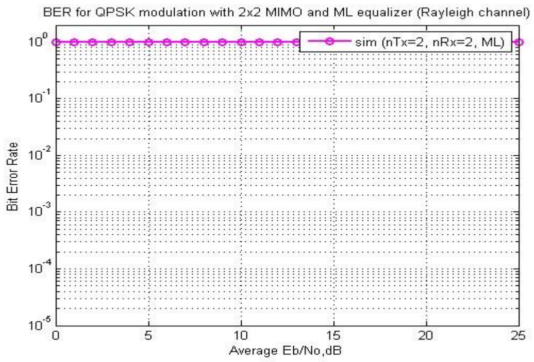

Fig.6. BER performance of QPSK Modulation for Rayleigh Fading and ML Equalizer

Fig.7 shows BER plot for BPSK in Rayleigh channel with 2X2 Alamouti STBC and MLD equalizers. Fig.8 shows the performance of STBC transmission using QPSK modulation with 2X2 Almouti STBC MLD equalizer. It can be seen from the figure that the BER decreases exponentially as SNR increases. For 5 dB Eb/No, the BER values of BPSK using ZF Equalizer 0.0687, BPSK using MLD Equalizer 0.0151, QPSK using ZF Equalizer 0.0070, QPSK using MLD Equalizer 1 is obtained. But BER Value for BPSK Modulation with 2X2 Almouti STBC and the BER Value for QPSK Modulation with same 2X2 Almouti STBC are obtained respectively as 0.0038 and 0.0034. The results indicate that the STBC multiplexing schemes show an overall improvement of ~67.95 dB between BPSK and QPSK modulation for the same 5 dB Eb/No 5 dB value. The STBC multiplexing for digital transmission shows significant improvement in BER performance with higher levels of digital modulation.

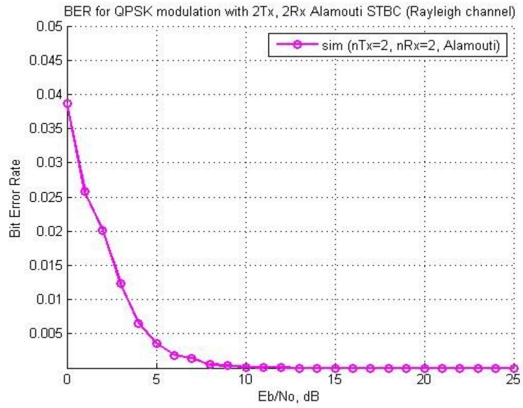

Fig.7. BER performance of QPSK Modulation for 2x2 Alamouti STBC

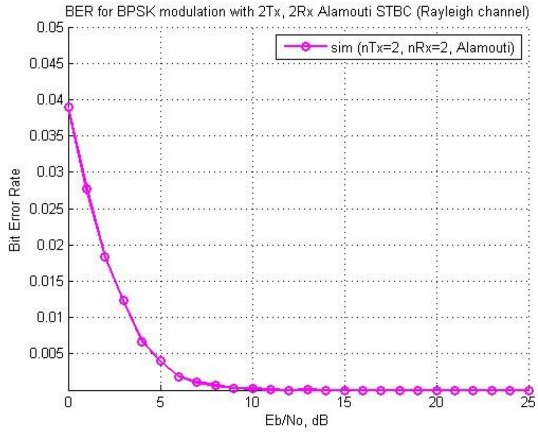

Fig.8. BER performance of BPSK Modulation for 2x2 Alamouti STBC

1. BER of BPSK and QPSK for 5dB SNR

Modulation	ZF Equalizer	MLD	Alamouti STBC
BPSK	0.0687	0.0151	0.0038
QPSK	0.0070	1	0.0034

V. CONCLUSION

This paper is devoted to study of transmission characteristics of MIMO system for different modulation techniques ,It can be concluded from the results presented above that,

1) For a MIMO system, the STBC multiplexing techniques and ZF and MLD receivers promotes achieving better SNR performances for digital transmission.
2) The BER of different modulation schemes such as BPSK and QPSK for 5dB SNR is calculated. It gives the best BER for Alamouti STBC coding compared to ZF and MLD Equalizer receivers for both BPSK and QPSK techniques. But BER value for BPSK and QPSK Modulation with 2X2 Alamouti STBC are obtained respectively as 0.0038 and 0.0034. The results indicate that the STBC multiplexing schemes show an overall improvement of ~67.95 dB between BPSK and QPSK modulation for the same 5 dB Eb/No value.

Published By:
Blue Eyes Intelligence Engineering and Sciences Publication (BEIESP)

VI. ACKNOWLEDGMENT

Aouther thankful to the Principal canara engineering college and HOD, Department of Electronics and communication, canara engineering college for their constant encouragement in carrying this research work

REFERENCES

1. M. Jankiraman,"Space –Time Codes and MIMO Systems", Artech House,2004.
2. S.M. Alamouti, IEEE Journal on Selected Areas in Communications, vol.16, pp. 1451-1458, October 1998
3. "DM Wireless Systems: Basics, Perspectives, and Challenges", IEEE Wireless Communications, Aug 2006, Pages 31 – 37.
4. R Bhagya, A G Ananth "Study Of Transmission Characteristics Of 2x2 Mimo System For Different Modulation Techniques Using Alamouti Stbc Coding And Zf, Mmse Equalizer Receivers", *JERS/Vol. II*/ Issue IV/October-December, 2011/208- 212.
5. Dr.Jacob Sharony, "Introduction to Wireless MIMO–Theory and Applications", IEEE LI, November 15,2006.
6. Shreedhar A Joshi, T S Rukmini, Mahesh H M, "Space Time Block Coding For Mimo Systems Using Almout Method With Digital Modulation Techniqes" World Journal of Science and Technology *2011, 1(8): 125-131 ISSN: 2231 – 2587*.
7. "Air Interface for Fixed Broadband Wireless Access Systems", IEEE 802.16-2001, IEEE standards for local and Metropolitan Area Networks Part16, April 2002.

AUTHOR PROFILE

Narendra M R received his B E Degree in Electronics and Communication and pursuing M.Tech Master Degree in Electronics from visvesvaraya Technological University, Belgaum, Karnataka, India, respectively in 2011 and 2013