PERFORMANCE ANALYSIS OF MIMO-OFDM SYSTEM USING SPACE TIME BLOCK CODES

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ABSTRACT:

This paper deals with BER analysis of MIMO Systems under different communication channels Additive White Gaussian Noise (AWGN) and Fading channel (Rayleigh and Rician). MIMO system uses Zero Forcing (ZF) decoder and Maximal Ratio Combining (MRC) at the receiver and encoded Alamouti STBC is used as transmit diversity. System performance in diverse modulation techniques such as BPSK, QAM and PAM is examined using MATLAB. Inorder to improve the bit error rate and symbol error rate , we also proposed LMS filtered based BPSK and LMS filter MRC. The simulated result shows that comparing the three different channel conditions, Rician fading channel has better performance. The Experiment results are obtained using Matlab software tool.

Keywords: *OFDM, MIMO, STBC, Fading Channels, LMS.*

1. INTRODUCTION

The increasing demand for modem communication systems is to provide high speed multimedia wireless services. There are various factors that degrade the performance of successful data transmission such as bandwidth is limited, loss in propagation, fading due to multipath, noise and interference [1]. Multiple antennas can be employed at the transmitter and receiver side to reduce fading outages and increase the capacity through spatial multiplexing or spatial diversity [2]. Wireless systems based on the MIMO technique are employed in applications that require high data rates. The choice of modulation schemes, additional antennas and signal processing chains are critical in the MIMO systems, this is added to the limitation of the antenna size especially for mobile. Realization of the benefits of the MIMO technique also depends on the coding scheme and complexity of the receiver. Hence MIMO has become an interesting area of research in wireless communication performance [3].

The information bits to be transmitted are encoded and mapped to data symbols such as BPSK, QAM and PAM by the symbol mapper [4]. These data symbols are send to Space Time Block Code (STBC) encoder which provide one or more spatial data streams to the transmit antennas. The signals propagate through the channel from the transmit antennas and reach the receiver antenna array. The receiver reverses the transmitter operations in order to decode the data followed by ZF decoder and MRC [5]. The objective of this paper is to analyze BER of MIMO Systems in different channel conditions where information is encoded by Alamouti STBC at transmitter, decoded by ZF and MRC at receiver. The encoded information is modulated using BPSK, QAM and PAM modulated schemes.

2. MIMO-OFDM TRANSMITTER AND RECEIVER

The MIMO-OFDM Transmiter and Receiver system is shown in Figure 1. At transmitter side, the information source generates the binary information to be transmitted. The binary information is converted to symbols for digital modulation. The modulated symbols are encoded by (Space time Block Code) STBC encoder and the reverse processes are carried out by different blocks at the receiver.

A. Transmitter

Transmitter consists of information source, modulator and STBC encoder.

Information Source

The Bernoulli binary generator block generates random binary numbers using a Bernoulli distribution. The Bernoulli distribution with parameter p produces zero with probability p and one with probability 1-p. The Bernoulli distribution has mean value 1-p and variance p (1-p). The probability of a zero parameter specifies p, and can be any real number between zero and one.

Symbol Modulation

The binary information generated by information source is too groups of bits to form binary symbols. These symbols are modulated using digital modulation schemes such as BPSK QPSK, 16-QAM and 64-QAM.

STBC Encoder

This block is used for space time diversity coding which is used to reduce the effect of noise and increase the bandwidth by reducing the Bit Error Rate. Alamouti [13] STBC is one of most important technique to achieve diversity using MIMO systems, and secure mean of exchange information. It is usually design under certain assumption and consideration of having knowledge about response of channel i.e. perfect channel state information (CSI) at

1.Transmitter site only

2.Receiver site only

3.The both site.

The block then transmits the encoded symbol by a space time block code to spread each of the N-transmit antennas according to the type of coding technique used.

B. Receiver

Receiver mainly consists of STBC decoder and demodulator.

STBC Decoder

This block is used for space time diversity decoding which is used to decode encoded data. It is usually design under certain assumption and consideration of having knowledge about response of channel.

Demodulation

The received data is demodulated by demodulator to get recovered data. This recovered data is compared with transmitted random data which gives Bit Error Rate (BER).

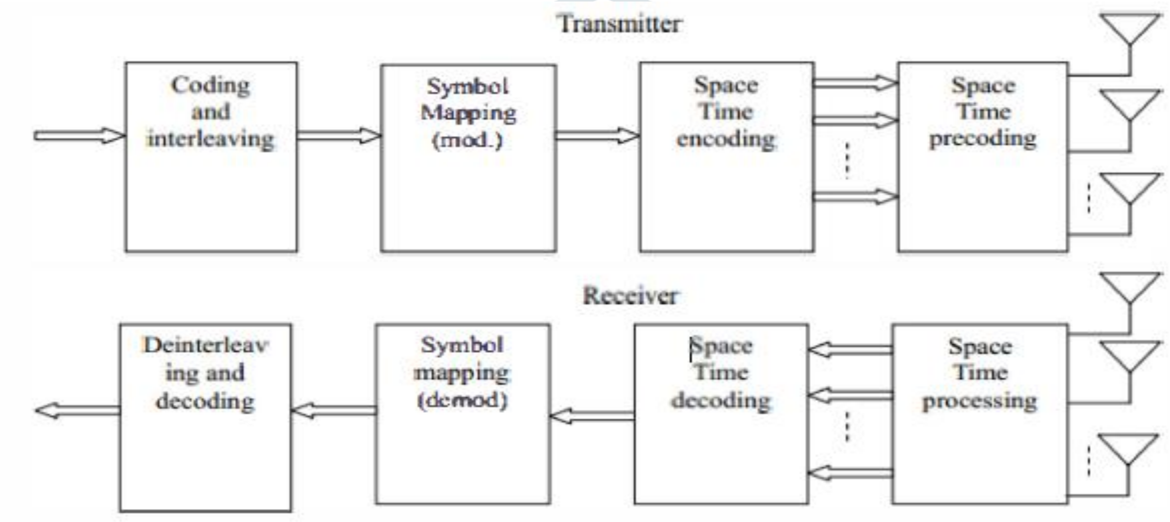


Fig 1. MIMO-OFDM Transmitter and Receiver

Space-Time Block Code (STBC)

Space–time block coding is a technique used in wireless communication 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. The fact that the transmitted signal must traverse a potentially difficult environment with 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 others. This redundancy results in a higher chance of being able to use one or more of the received copies to correctly decode the received signal.[14][15]

3. TYPES OF CHANNELS

a. Additive White Gaussian Noise (AWGN)

AWGN is a channel model in which the only impairment to communication is a linear addition of wideband or white noise with a constant spectral density expressed as watts per hertz of bandwidth and a Gaussian distribution of amplitude. The model does not account for

fading, frequency selectivity, interference, nonlinearity or dispersion. In the study of communication systems, the classical (ideal) AWGN channel, with statistically independent Gaussian noise samples corrupting data samples free of inter-symbol interference (ISI), is the usual starting point for understanding basic performance relationships. An AWGN channel adds white Gaussian noise in the signal that passes through it.[13]

b. Rayleigh Fading Channel

Rayleigh fading is a statistical model for the effect of a propagation environment on a radio signal such as that used by wireless devices. It assumes that the power of a signal that has passed through such a transmission medium (also called a communications channels) will vary randomly or fade according to a Raleigh distribution, the radial component of the sum of two uncorrelated Gaussian random variables. It is reasonable model for tropospheric and ionospheric signal propagation as well as the effect of heavily built up urban environment on radio signals. Raleigh fading is most applicable when there is no line of sight between the transmitter and receiver. In a multipath propagation environment, the received signal is sometimes weakened or intensified. [12][13]

c. Rician Fading Channel

Rician fading is a stochastic model for radio propagation anomaly caused by partial cancellation of a radio signal by itself. The signal arrives at the receiver by several different paths (hence exhibiting multipath interference), and at least one of the paths is changing (lengthening or shortening). Rician fading occurs when one of the paths, typically a line of sight signal, is much stronger than the others. [12][13]

4. BIT ERROR RATE ANALYSIS

A. BER

The no. of bit errors is the number of receiving bits of a signal data over a communication channel that has been changed because of noise, distortion and interference [14]. The bit error rate or BER is defined as the rate at which errors occur in a transmission system during a finite time interval. BER is expressed as a percentage or 10 to the negative power. BER formula is give as follows

BER = number of errors / total number of bits sent

B. SNR

The SNR is the ratio of the received signal power over the noise power in the frequency range of the process. SNR is inversely proportional to BER. Throughput decreases if BER increases due to packet loss and delay. SNR is used to measure the clarity of the signal in a wired/wireless transmission channel and measure in decibel (dB). The SNR is the ratio between the wanted signal and the unwanted background noise as given in Equation

$$SNR = \frac{P_{signal}}{P_{noise}}$$

SNR formula in terms of diversity is given by Equation (16)

$$BER = \frac{1}{SNR^d}$$

C. BER of Zero Forcing

Zero forcing equalizer cancels out all the interferers but noise can be amplified, hence Zero forcing equalizer is simple, easy to implement but not fit for best possible equalizer. BER for ZF equalizer [15] is defined as

$$P_b = \frac{1}{2}\left(1 - \sqrt{\frac{E_b/N_0}{E_b/N_0 + 1}}\right)$$

where P_b is the Bit Error Rate and E_b/N_o is Signal to noise Ratio

D. BER of Maximal Ratio Combining

Using BPSK Modulation considering A WGN channel, the bit error rate is given in Equation

$$P_b = \frac{1}{2} erfc\left(\sqrt{\frac{E_b}{N_0}}\right)$$

The SNR with MRC is denoted as γ , where bit error rate total is the integral of the conditional BER integrated over all possible values of γ [16]. This Equation reduces to

$$P = \frac{1}{2} - \frac{1}{2}\left(1 + \frac{1}{E_b/N_0}\right)^{-\frac{1}{2}}$$

5. LMS ALGORITHM

Although being more practical in its use than the Newton's method, the steepest descent algorithm has an important restriction in that it still requires the estimate of the gradient to be computed in an off-line fashion for many cases. The LMS algorithm appears first to overcome this necessity by employing an instantaneous estimate of the gradient in the steepest-descent algorithm rather than a long-term average, and it has been recognized as one of the most practical adaptive algorithms.

The conventional LMS algorithm in estimating a flat-fading communication channel is given

$$f_{k+1} = f_k + 2\mu e_k a_k$$

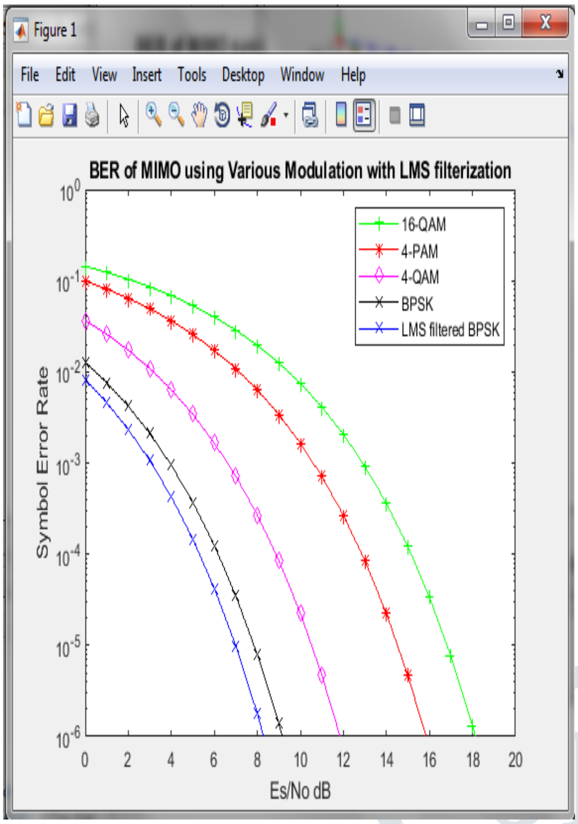
where *fk* is the estimate of the fading coefficient, *ak* is the input symbol, µ is the step-size value of the algorithm and *ek* is the estimation error given for this particular case as

$$e_k = y_k - f_k a_k$$

where *yk* is the associated observation symbol.

6. RESULTS:

Figure. 6.1, shows SNR vs SER performance of MIMO OFDM using different modulation schemes under different channel. A lower modulation scheme gives better SER performance as compared to higher modulation schemes..



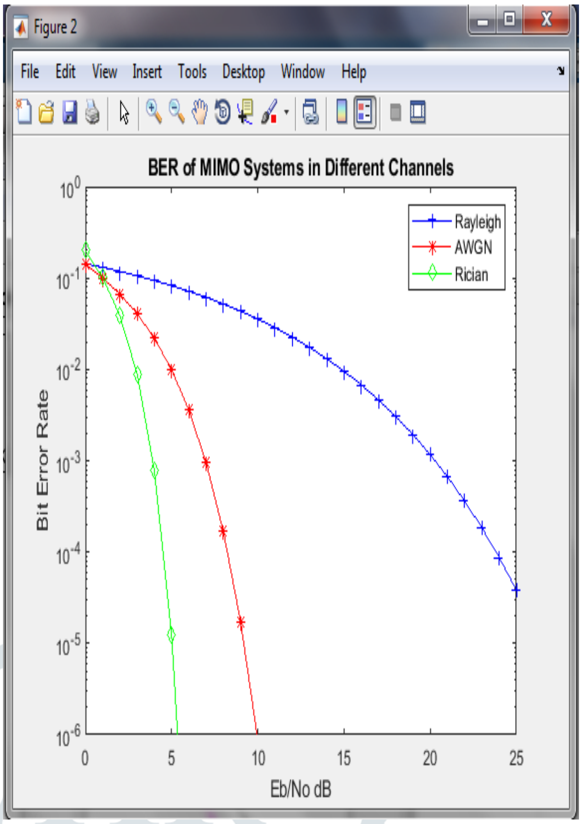


Figure 2. SNR vs SER Figure 3. SNR vs BER

Figure 2 shows SER vs SNR performance of MIMO using different modulation schemes under different channel. LMS Filtered BPSK scheme gives better SER performance as compared to other modulation schemes. From fig.6.1 at SNR 8.5 dB 16-QAM gives SER value $10^{-1.2}$ where as in 4-PAM gives SER $10^{-1.6}$, 4-QAM gives SER value 10^{-3} and BPSK gives $10^{-4.5}$, LMS filtered BPSK gives $10^{-5.5}$

The performance is compared using three diferent channel i.e AWGN, Rayleigh and Rician channel. The BER with respect to SNR is shown in fig 3.

From figure 3 it is clearly shown that Rician channel having good performance in terms of BER. According to the results obtained, Rician channel need to be considered to avoid loss of bit. When we consider 5db , the BER for rayleigh channel is 10^{-1} which means out of 10bits there is an 1 bit of error probability, for AWGN channel at 5db the BER id $10^{-1.5}$ and finally for Rician channel the BER is 10^{-5} which means out of 10000 bits there is a probability of 1 bit error.

Hence communication channels need to prefer Rician channel while transmitting of data from source to destination. Inorder to reduces the bit error rate at receiving end we implement techniques like ZF, MRC, LMS MRC and the results are compared in figure 4.

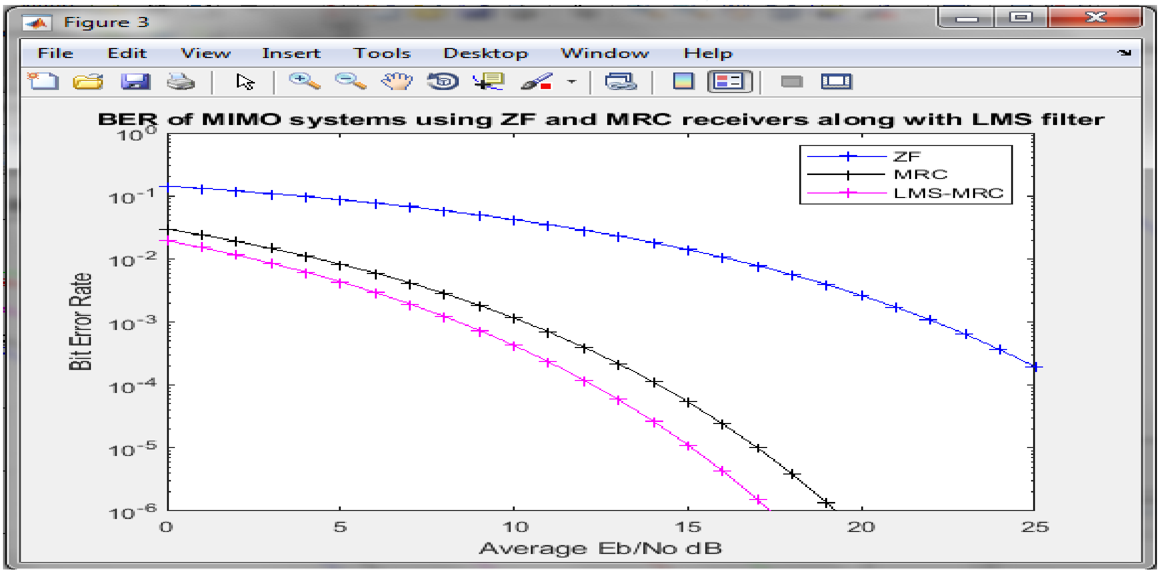


Fig 4. Average SNR vs BER

7. CONCLUSION:

MIMO system Performance is analyzed using different Modulation schemes in different channel conditions with STBC encoder, ZF and MRC receivers. The BER performance of Rician channel in MIMO system is much better than that of AWGN and Rayleigh channel using BPSK Modulation. Comparing the Equalization technique, MRC is the best Equalization technique for MIMO systems. According to the simulation parameters, comparing BPSK modulation, 4- QAM, 16-QAM and 4-PAM, it is observed that BER is low

for BPSK, so BPSK Modulation scheme is the best modulation technique for data transmission that is suitable for the Rician channel and also for MRC equalizers. Compared to BPSK and MRC equalizers, the proposed LMS filter based BPSK and LMS filter based MRC show better performance results.

REFERENCES:

[1] Tarokh v, Naguib A, Seshadri N and Calderbank,A. R, " Combined Array Processing and Space-Time Coding," IEEE Transactions on Information Theory, vol. 45, no. 4,1999.

[2] N. Kaur & L. Kansal, "Performance Comparison of MIMO Systems over A WGN and Rician Channels with Zero Forcing Receivers", International Journal of Wireless & Mobile Networks, Vol. 5, Issue I, pp. 73-84,2013.

[3] A. S. Mindaudu and A. M. Miyim, "BER Performance of MPSK and MQAM in 2x2 Almouti MIMO Systems", International Journal of Information Sciences and Techniques (!JIST) Vol.2, No. 5, September 2012.

[4] Simon, M. K. and Alouini (2004), M. Digital Communication over Fading Channels. John Wiley & Sons, 2004.

[5] G. J. Foschini and M. J. Gans, "On limits of wireless communications in a fading environment when using mUltiple antennas", Wireless Personal Communications, Mar. 1998, pp. 311-335.

[6] V. K. Garg and J . E. Wilkes, Wireless and Personal Communications Systems , Prentice Hall, 1996.

[7] D. Wubben, R. Bohnke, J. Rinas, V. Kuhn and K . D. Kammeyer, "Efficient algorithm for decoding layered space-time codes", Electronics Letters, vol. 37, pp. 1348-1350,2001.

[8] S. M. Alamouti, "A simple transmitter diversity technique for wireless communications", IEEE Journal on Selected Areas Communication, Vol. 16, No. 8, pp. 1451-1458, 1998.

[9] G. Arslan, B. L. Evans, and S. Kiaei, "Equalization for Discrete Multitone Receivers To Maximize Channel Capacity", IEEE Transactions on Signal Processing, submitted March 2000.

[10] S. M. Alamouti, "A simple transmit diversity technique for wireless communications," IEEE Journal on Selected Areas in Communications, vol. 16, no. 8, pp. 1451-1458, 1998.

[11] Arunabha Ghosh, David R. Wolter, Jeffrey G. Andrews and Runhua Chen "Broadband Wireless Access with WiMaxl802.16: Current Performance Benchmarks and Future Potential", IEEE Communication Magazine, Vol. 43, No. 2, pp. 129-136,2005.

[12] Van de Beek, J. Edfors, O. Sandell, M. Wilson, S.K. Borjesson and P. O., "On channel estimation in OFDM systems", In proceedings of 45th IEEE Vehicular Technology Conference, vol.-2, Issue 7, pp. 815-819,1995.

[13] Navjot Kaur and Lavish Kansal, " Performance Comparison of MIMO Systems over A WGN and Rician Channels using OSTBC4 with Zero Forcing Receivers," International 10urnal of Engineering & Computer Science !JECS-IJENS Vol:13 No:02

[14]1ignesh B. Jethva, "Performance Analysis of MIMO OFDM System for Different Modulation Schemes under Various Fading Channels, International Journal of Advanced Research in Computer and Communication Engineering Vol. 2, Issue 5, May 2013

[15] Dhruv Malik I , Deepak Batra, "Comparison of various detection algorithms in aMIMO wireless communication receiver", International Journal of Electronics and Computer Science Engineering.

[16] Nisha Achral, Garima Mathur, Prof. R.P. Yadav, "Performance Analysis of Wireless MIMO System by Using Alamouti's Scheme and Maximum Ratio Combining Technique" Dept. of Electrical and Electronic Engineering, 2011.