International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 5 Issue 05, May-2016

Bit Error Rate Performance of the OFDM MIMO System in Different Fading Channels

K. N. V. Suresh Varma
Electronics and communications
SRKR Engineering College
Bhimavaram, India

N.V. Phani Sai Kumar
Electronics and communications
SRKR Engineering College
Bhimavaram, India

Abstract **-In this paper we observe the performance of MIMO-OFDM system in different channels such as Rayleigh channel, Rician channel and AWGN channel with respect to the bit error rate performance (BER). At the transmitter side we employ golden code encoding, a new type of space time coding with full rate and full diversity and at the receiver side we perform sphere decoding rather than ML decoding and MMSE equalizer for decreasing the complexity of decoding.**

Keywords— Golden Code Sphere Decoding,Bit Error Rate, OFDM MIMO,MMSE

I. INTRODUCTION

The demand for wireless communication has increased because of increased data rates and less power consumption for the 3G and 4G applications. Orthogonal Frequency Division Multiplexing (OFDM) is a splendid technique for minimizing the unacceptable Inter Symbol Interference (ISI). Using OFDM the single data stream to be transmitted is divided in to multiple sub streams such that each sub stream has less data rate when compared to the data rate of entire data stream and each sub stream is modulated with an individual sub carrier such that all the sub carriers are orthogonal to each other. MIMO systems can provide high data rates and increased reliability and also increase the capacity of the system because of increased data rates by efficiently utilizing the available bandwidth there by increasing the spectral efficiency. Bit error rate (BER)is one of the important issue by which we can determine the performance of a communication system. Bit error rate is give by number of bits in error to the total number of transmitted bits. As the number of error bits increases BER of the communication system will also get increased. ZF Equalizer and MMSE equalizer are the two basic equalizers that can be used at the receiver side for proper detection of the received signal .The main purpose of an equalizer is to remove the unwanted noise and inter symbol interference(ISI) .Of the two equalizers,(BER) bit error rate performance of MMSE equalizer is superior to that of ZF equalizer in terms of the decoding performance. In this paper, I mainly concentrate on the bit error rate performance of the system lot of research work has been done on MIMO-OFDM system related to bit error rate

Several high data rate schemes has been proposed and space time codes has been proposed for providing reliable communication between the transmitter and the receiver. golden code is one of the space time block codes which is superior when compared to the previous space time block codes such as alamouti code , repetition code and VBLAST code. But the most widely used codes are alamouti code and the golden code. Golden code is a 2*2 algebraic space time block code constructed using cyclic division algebras. Cyclic division algebras are a particular family of division algebras that can be used to construct codes with full rate and full diversity. Hence, golden code can achieve full rate as well as full diversity. Here code rate is the number of symbols that are transmitted per time slot to the total number of time slots that are used for transmitting a code word. In case of golden code, codeword is a 2*2matrix such that four symbols are transmitted for two time slots and hence it achieves a full rate of two which is equal to the number of transmitting antennas. In this paper, we used a 2*2 MIMO system and at the receiver side sphere decoding is implemented for decoding the received data. Brute force ml decoding can also be performed but it has more complexity and hence sphere decoding is used. finally, in this paper the BER performance of the MIMO OFDM system for different fading channels such as Rayleigh fading channel , rician fading channel and AWGN channel are observed.

II. SYSTEM MODEL DESCRIPTION

The data to be transmitted is first generated randomly. Here, I use mat lab coding for generating the data. In case of Simulink the data can be generated using Bernoulli binary generator. After generating the data, it is then QAM modulated. We perform 32 QAM modulation. Now the QAM modulated data is space time encoded using golden code. Golden code is a perfect space time block code that can achieve full rate and full diversity; it can also achieve diversity multiplexing tradeoff.

Properties of the golden code are :

FULL RANK: A code is said to have full rate if we consider any two code words in the code book then the determinant of the difference matrix of that code words is a non-zero maximum value.

FULL RATE: it is the maximum number of symbols that can be transmitted per time slot. Using golden code four symbols are transmitted i.e., four degrees of freedom are used.

Algebraic space time codes (ASTC) in general are classified in to three categories. They are golden code (GC), threaded algebraic space time code (TAST) and diagonal algebraic space time code (DAST).

All the modulated data that is to be transmitted is divided in to two stream constellations by the ASTC encoder i.e., golden code encoder. The primary operation of ASTC encoder is to determine the value relying on the matrix. The encoded codeword is represented as shown below.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 5 Issue 05, May-2016

$$X = \frac{1}{\sqrt{5}}\begin{bmatrix} \alpha(a+b\theta) & \alpha(c+d\theta) \\ \sigma(\alpha)(c+d\sigma(\theta)) & \sigma(\alpha)(a+b\sigma(\theta)) \end{bmatrix}$$

Where

$$\theta = \frac{1+\sqrt{5}}{2} \qquad \sigma(\theta) = \frac{1-\sqrt{5}}{2}$$

$$\alpha = 1+i-i\theta \quad \sigma(\alpha) = 1+i-i\sigma(\theta)$$

Here a, b, c, d are the information symbols taken from the QAM constellation. a, b, c, d can take any values from Z[i]. Here, Z[i] is the integer lattice containing the set of integers along with i and all its multiples. In general, the transmission model for MIMO system is given by

$$Y=HX+N$$

Where H is the channel matrix

X is the transmitted codeword matrix and

W is the channel matrix

In the golden code, the encoded codeword matrix X is the result of multiplication of the each four successive information symbols with the matrix shown below

$$\emptyset = \frac{1}{\sqrt{5}}\begin{bmatrix} \alpha & \alpha\theta & 0 & 0 \\ 0 & 0 & i\sigma(\alpha) & i\sigma(\alpha)\sigma(\theta) \\ 0 & 0 & \alpha & \alpha\theta \\ \sigma(\alpha) & \sigma(\alpha)\sigma(\theta) & 0 & 0 \end{bmatrix}$$

The channel is assumed to be quasi static and the system is coherent i.e.., perfect channel state information (CSI) is available at the receiver.

Here, Brute Force ML decoding can be used as ASTC decoder to recover the original data, but it has more complexity. Hence in this paper we used sphere decoding for decreasing the complexity of decoding. In ML decoding, the decoder searches for the matrix by computing an estimate of the transmitted matrix with minimum noise power. This can be represented by the equation shown below.

$$X^{*}=\arg\min_{X}\|Y-HX\|^{2}$$

But because of the high complexity of the ML decoding we have chosen sphere decoding. In sphere decoding, it searches for the closest constellation point to the received signal with in a sphere of some initial radius. If a point and the dimension between the center and the point is less than the radius, the radius is updated to the shortest distance and the process is repeated till only a single point is left in the sphere.

By encoding the signal, the input data stream is converted into matrix form. Then, interleaving is performed on the coded data by using matrix interleaver and block interleaver. Here the matrix interleaver fills the input symbols row by row. Correspondingly at the receiver side opposite to interleaving i.e., de interleaving is performed on the received.

Coming to channels that are used in this paper are namely Rayleigh channel, rician channel and additive white Gaussian noise channel, these channels are described below

a)Rayleigh channel: The attenuation of the signal in Rayleigh channel follows Rayleigh distribution where the component is the sum of the two uncorrelated Gaussian random variables. Due to multi path propagation berween the transmitter and the receiver there exists constructive and destructive interference on the received signal and also shift in the phase of the signal resulting in Rayleigh fading. There is no direct line of sight path between the transmitter and the receiver and the equation for the received signal is given by

$$R(n) = H(n, l)\, S(n-m) + w(n)$$

Here w (n) is the AWGN noise having zero mean and variance as unity. H (n) is the impulse response of the channel and it is given by

$$H(n) = \alpha(n)e^{-j\theta(n)}$$

Here θ and α are the phase shift and attenuation of the nth path respectively. A channel is said to be flat fading channel if the coherence bandwidth of the signal is larger than the signal bandwidth and if the coherence bandwidth is less than the signal band width then it is termed as frequency selective fading channel. In this paper we use frequency selective fading channel.

b)rician fading channel:

The attenuation of a signal in rician fading channel is due to the partial cancellation of the radio radiation by itself. The signal arrives at the receiver travelling through multi paths and the shortest or longest path between the transmitter and receiver is not constant and changes with time. Rician fading occurs in all the ways .In general, in the Line of sight LOS path of signal than other paths. In rician fading model ,the amplitude gain follows rician distribution.

The rice factor is given by

$$k = \frac{m}{2\sigma^2}$$

This factor is useful in giving the relative strength of the direct line of sight path component. If the k value is zero then it becomes Rayleigh channel and if k value is infinity then it becomes AWGN channel.

In digital communications to allow recovery of the symbols with reduced inter symbol inter symbol interference efficient equalizers such as MMSE can be used. when compared to MMSE, ZF equalizer does not give best error performance as it does not take noises in to account whereas MMSE equalizer take noises into account. It is based on the mean square error (MSE) criteria. A linear equalizer H_e (Z) is chosen to minimize the MSE between output of equalizer and the original information symbols

The linear MMSE equalizer can also be found iteratively firstly, we check whether MSE is a quadratic function. The gradient of MSE with respect to h_e determines the direction in which is the h_e is to be changed for getting MSE as the largest value. For decreasing the MSE, H_e is to be modified in the direction opposite to the gradient. This is called as least mean square (LMS) algorithm.

III.SIMULATION RESULTS

Here the matlab simulink R2012.a is used for simulation of the results on Bit error rate performance (BER) vs Eb/No. Figures (1-3) shows the simulation results of OFDM MIMO system in the presence of different fading channels such as Rayleigh channel, rician channel and AWGN channel using MMSE equalizer.

Fig.1 shows the BER performance of OFDM MIMO system in Rayleigh fading channel. Here, in the simulation results we can observe that as signal to noise ratio (SNR) increases bit error rate of the system decreases monotonically.

Fig.2 shows the simulation results in rician fading channel for the OFDM MIMO system. It achieves a bit error rate of nearly 10^{-5} at an SNR of 35dB and in the graph we can observe that with the increase in the SNR the BER decreases monotonically.

Fig.3 shows the simulation results of the system in the presence of AWGN channel. Here the results are compared using golden code encoding at the transmitter and MMSE equalizer at the receiver side with the results obtained without using golden code at the transmitter. The results obtained with the proposed work give better performance of 10-5 at an SNR of 6dB only.

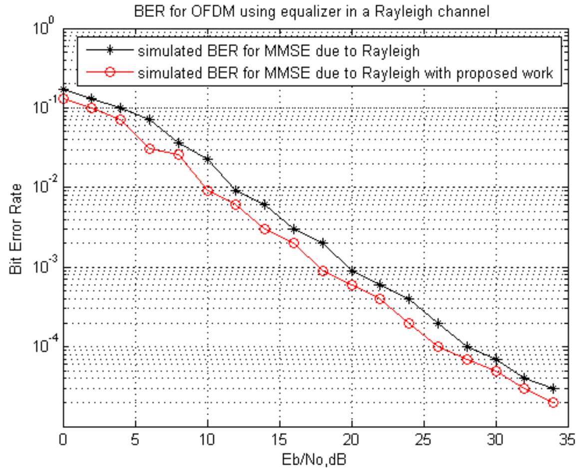

Fig.1 BER performance of MIMO OFDM in Rayleigh channel

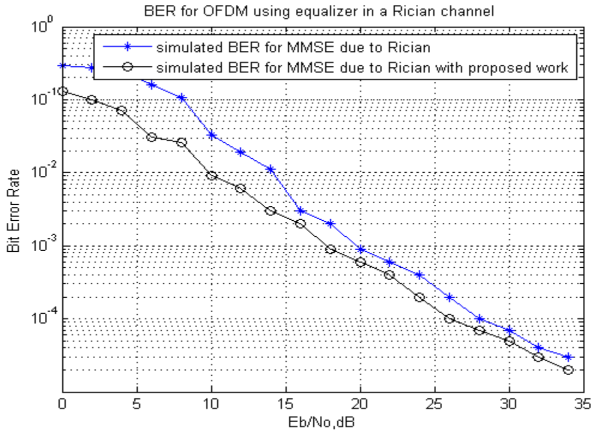

Fig.2 BER performance of MIMO OFDM in Rician channel

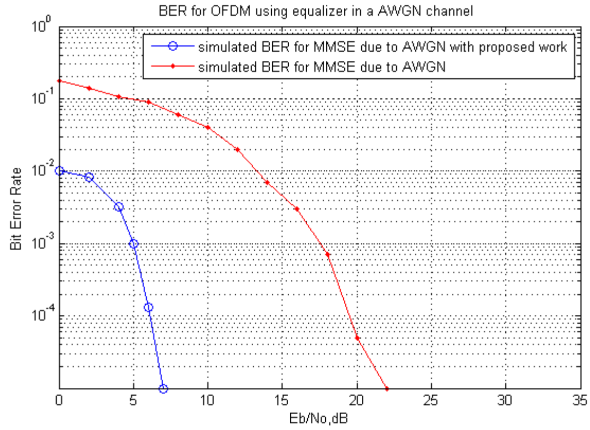

Fig.3 BER performance of MIMO OFDM in AWGN channel

IV.CONCLUSION

In this paper we observed the bit error rate performance of the OFDM MIMO system in different channels such as Rayleigh channel, rician channel and AWGN channel and from the observation we can say that both the Rayleigh and rician channel give similar performance i.e., at an Eb/No of 35 dB we get nearly 10^{-5} as the bit error rate where as in AWGN channel we get the BER of 10^{-5} at an Eb/No of 20 dB and 5 dB.

V.REFERRENCES

[1] J. C. Rekaya, G. Viterbo, and E. Belfiore: The golden code: a 2x 2 full-rate space-time code with non-vanishing determinants , *IEEE Trans. Inf. Theory*, vol.51 (4), pp.1432, (2005).

[2] S. Ebert and P. Weinstein: Data Transmission by Frequency-Division Multiplexing Using the Discrete Fourier Transform,*IEEE Trans. Commun. Technol.*, vol.19 (5), pp.628, (1971).

[3] H. Sari, G. Karam, and I. Jeanclaude : An analysis of orthogonal frequency-division multiplexing for mobile radio application,*IEEE 44th Vehicular Technology Conf.*, Stockholm, Sweden, Vol. 13, pp. 1635-1639, June 8-10 ,1994,

[4] H. Bolcskei, D. Gesbert, and A. J. Paulraj: On the Capacity of OFDM-Based Spatial Multiplexing Systems, *IEEE Trans. On Commun.*, vol.50(2), pp.225 (2002).

[5] B.Gupta, G. Gupta and D.S.Saini: BER performance improvement in OFDM system with ZFE and MMSE Equalizer,*IEEE 3rd Int. Conf. on Electronics Computer Techno. (ICECT)*,Kanyakumari, pp.193, April 2011.

[6] A. K Jaiswal, A. Kumar and P. S Anand: Performance analysis of MIMO-OFDM in Rayleigh fading channel, *Int. Journal of Scientific and Research* publication, vol. 2(5),pp.1-5, (2012).

[7] M. Lal and H. Arora: BER Performance of Different Modulation Schemes for MIMO Systems, Int. *Journal of Computer Science and Network Security*, vol.*11,No.3,pp.69-72 (2011).*

[8] K.Vidhya and K.R.S. Kumar**:** BER Performance of MIMOOFDM System using STTC, *Int. Journal of Scientific and Research Publications*, vol.3,issue.2,pp.1-5(2013).

[9] H. Bolcskei : MIMO-OFDM wireless systems: basics, perspectives, and challenges *IEEE Wireless Commun.*, vol.13(4), pp.31–37 (2006).

[10] J. C. Rekaya, G. Viterbo, and E. Belfiore: The golden code: a 2 x 2 full-rate space-time code with non-vanishing determinants, *IEEE Trans. Inf. Theory*, vol.51 (4), pp.1432, (2005).

[11] A. Bannour, M. L. Ammari, and R. Bouallegue : Analysis of ASTC in a correlated rayleigh fading channel with imperfect channel estimation, in Proc. of *Int. Conf. on Advanced Commun. Technol. (ICACT'2010)*, Phoenix Park, USA, Feb 7-10, Vol. 2, pp. 1300, 2010.

[12] A. Bannour, M. Ammari, and R. Bouallegue: Analysis of ASTC in a correlated rayleigh fading channel with imperfect channel estimation, in *7th Int. Sym. on Wireless Commun. Systems (ISWCS), New York*, pp. 159, Sep 19-22, 2010.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 5 Issue 05, May-2016

[13] A. Bannour, M. Ammari, Y. Sun, and R. Bouallegue : On the Capacity of ASTC-MIMO-OFDM System in a Correlated Rayleigh Frequency-Selective Channel ,*IEEE 73rd Vehicular Technology Conf. (VTC Spring)*, Budapest, pp.1, May 15-18,2011.

[14] J. G. Proakis, *Digital Communication* Edition: 5th (New York McGraw-Hill Series in Electrical and Computer Engineering,(2007).

[15] V. Tarohk N. Seshadri and A. R. Calderbank : Space-time block codes for high data rate wireless communications: performance criterion and code construction *IEEE Trans. Inform. Theory*, vol.44 (2) pp. 744, (1999).

[16] J. Van de Beek, O. Edfors, M. Sandell *et al*.: On channel Estimation in OFDM systems, in Proc. of *IEEE 45th Vehicular Technology Conf*., Chicago, Vol.2 (7), pp. 815, 1995.

[17] S. S. Sarnin, N. Kadri and A. Mahyuni: Performance Analysis of BPSK and QPSK Using Error Correcting Code through AWGN, in Proc. *IEEE Int. Conf. on Networking and Information Technology (ICNIT 10)*, Manila, pp.178, June 11- 12, 2010.

[18] A. Chandra, D. Biswas and C. Bose: BER Performance of Coherent PSK in Rayleigh Fading Channel with Imperfect Phase Estimation, in Proc. of *IEEE Int. Conf. on Recent Trends in Information, Telecommunication and Computing (ITC 10)*,Kochi, Kerala, pp.130, March 12-13, 2010.

[19] M. X. Chang and Y. T. Su: Performance Analysis of Equalized OFDM Systems in Rayleigh Fading ,*IEEE Trans. on Wireless Commun*., vol.1(4),pp.721,(2002).

[20] Sklar: Rayleigh Fading Channels in Mobile Digital Communication Systems Part I: Characterization, in *IEEE Comm. Mag*., vol.35 (7), pp.90, (1997).

[21] P. Bhatnagar, J. Singh, M.Tiwari: Performance of MIMOOFDM System For Rayleigh Fading Channel, *Int. Journal of Science and Advanced Technology*, vol.1(3), (2011).

[22] W. Lindsey: Error probabilities for Rician fading multichannel reception of binary and N-array signals, *IEEE Trans. Inf. Theory*, vol.10(4),pp.339, (1964).