IOSR Journal of Electronics and Communication Engineering (IOSR-JECE)
e-ISSN: 2278-2834,p- ISSN: 2278-8735.Volume 6, Issue 4(May. - Jun. 2013), PP 12-18
www.iosrjournals.org

Error Control and performance Analysis of MIMO-OFDM Over Fading Channels

C.Nithiya[1], R.Rani kowsalya[2], M.Prabakaran[3]
[1](*Student, ECE, Arasu Engineering College, India)*
[2](*Student, ECE, Arasu Engineering College, India)*
[3](*Assistant Professor, ECE, Arasu Engineering College, India)*

ABSTRACT: *Multiple Input Multiple Output is a wireless technology that uses multiple transmitters and receivers to transfer more data at the same time. Orthogonal Frequency Division Multiplexing, an FDM modulation technique which splits the signal into multiple smaller sub-signals that are then transmitted simultaneously at different frequencies to the receiver. OFDM technique spreads the data over number of carriers which are at specific predefined frequencies. This reduces or eliminates the ISI. Forward error correction or channel coding is a technique used for controlling errors in data transmission over unreliable or noisy communication channels. The objective of our proposed paper is to implement the FEC into the MIMO OFDM systems and its performance is analysed by using MATLAB over different fading channels. For modulation it employs M-QAM which combines both ASK and PSK thereby enabling several bits to be transmitted per symbol. The performance of MIMO-OFDM system is evaluated by BER Vs SNR when the bits propagates through the different fading channels.*
Keywords– *OFDM, MIMO, QAM, FEC, BER.*

I. Introduction

MIMO-OFDM combines OFDM and MIMO techniques thereby achieving spectral efficiency and increased throughput. A MIMO-OFDM system transmits independent OFDM modulated data from multiple antennas simultaneously. At the receiver, after OFDM demodulation, MIMO decoding on each of the subchannels extracts the data from all the transmit antennas on all the subchannels. With this MIMO-OFDM technology, a wireless LAN can accommodate latency-sensitive, bandwidth intensive multimedia applications such as HDTV streaming, provide the throughput-at-range for reliable coverage area.

A. Orthogonal Frequency Division Multiplexing

Orthogonal frequency division multiplexing (OFDM**)** is a multi-carrier transmission technique that has been recently recognized as an excellent method for high speed bi-directional wireless data communication. Its history dates back to the 1960s, but it has recently become popular because economical integrated circuits that can perform the high speed digital operations necessary have become available. OFDM effectively squeezes multiple modulated carriers tightly together, reducing the required bandwidth but keeping the modulated signals orthogonal so they do not interfere with each other. Today, the technology is used in such systems asymmetric digital subscriber line (ADSL) as well as wireless systems. OFDM is similar to FDM but much more spectrally efficient by spacing the sub-channels much closer together. This is done by finding frequencies that are orthogonal, which means that they are perpendicular in a mathematical sense, allowing the spectrum of each sub-channel to overlap another without interfering with it. In order to demodulate the signal, a discrete Fourier transform (DFT) is needed. Fast Fourier transform (FFT) chips are commercially available, making this a relatively easy operation. The block diagram of the OFDM system is shown in the fig.1.

One of the main advantages of OFDM techniques resides in their ability to combat multipath fading without the need for complex equalization techniques. Another advantage is the high spectral efficiency achieved by mapping the modulated data onto several orthogonal carriers, with the conjunction of high-order modulations like M-QAM. OFDM is considered for many projects such as Digital Audio Broadcasting (DAB), Digital Video Terrestrial-Broadcasting (DVB-T), Digital Radio mandible (DRM), Asynchronous Digital Subscriber Line (ADSL) and so on.

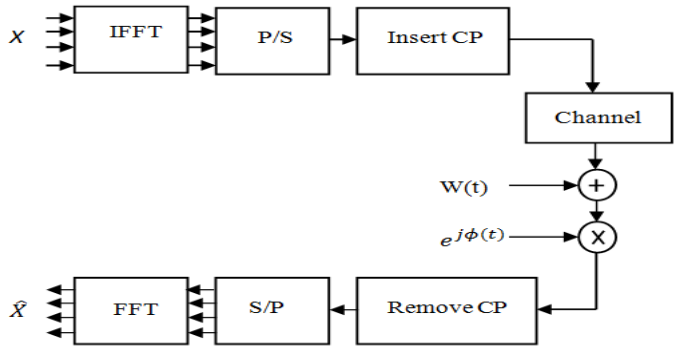
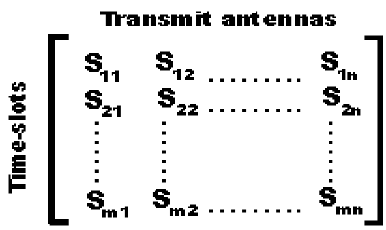


Fig.1 OFDM TRANSCEIVER

B. Multiple Input Multiple Output (Mimo)

MIMO is effectively a radio antenna technology as it uses multiple antennas at the transmitter and receiver to enable a variety of signal paths to carry the data, choosing separate paths for each antenna to enable multiple signal paths to be used. . The principle of diversity is to provide the receiver with multiple versions of the same signal. If these can be made to be affected in different ways by the signal path, the probability that they will all be affected at the same time is considerably reduced. Accordingly, diversity helps to stabilise a link and improves performance, reducing error rate. To gain the maximum capacity of MIMO wireless channel one of the efficient procedures is to utilize space time coding. In STC, the multiple copies of information are transmitted for achieving diversity is extracted from a space time encoder which encodes a single bit through space and time. So coding is done in both spatial and temporal axis to correlate the transmitted signal from various transmit antenna at a different time. A particularly elegant scheme for MIMO coding was developed by Alamouti. The associated codes are often called MIMO Alamouti codes or just Alamouti codes. The space time block code matrix is given by,



MIMO system consists of three components, mainly transmitter, channel and receiver. Transmitter sends a multiple data such as $x_1, x_2, x_3 \ldots\ldots x_n$ from different transmit antenna and signal is received by each receive antenna $r_1, r_2, r_3 \ldots\ldots r_n$ simultaneously. The relation between transmit data and receive data is given by

$$r_1 = h_{11} x_1 + h_{12} x_2 + \ldots + h_{1N} x_N,$$

$$r_2 = h_{21} x_1 + h_{22} x_2 + \ldots + h_{2N} x_N,$$

...

$$r_N = h_{N1} x_1 + h_{N2} x_2 + \ldots + h_{NN} x_N.$$

Where, r=Received Signal Vector; H=Channel Matrix; n= Noise Vector.

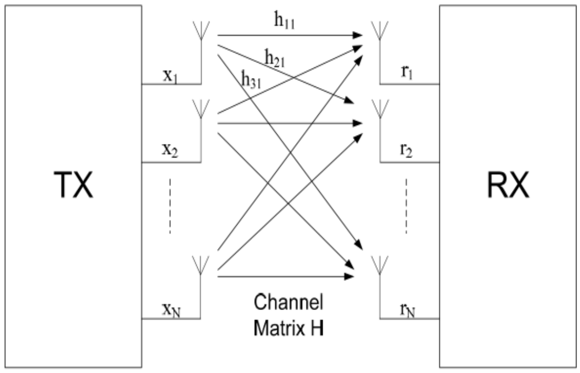


Fig.2 MIMO TRANSCEIVER

The new transmit diversity scheme was introduced by Alamouti known as Alamouti scheme. Alamouti scheme uses two transmit antenna and N receive antenna and can have a maximum diversity order of 2N. Alamouti scheme has the rate of unity i.e. full rate since it transmits two symbols after every two time periods. This scheme is efficient in all the applications where system capacity is limited by multipath fading.

Let us assume a signal s1 and s2 are transmitted by antenna 1 and antenna 2 respectively at time t. At next time t+T signal $-s_2$ * is transmitted from antenna 1 and signal s_1 * is transmitted from antenna 2 where (*) is the complex conjugate operation.The Encoding and Transmission Sequence for Alamouti 2x1 transmission scheme is given below.

Multiple-Input Multiple-Output uses multiple antennas at both sides which provides transmit diversity and receiver diversity. It's applicable in every kind of networks like PAN, LAN, WLAN, WAN, MAN. MIMO system can be applied in different ways to receive either a diversity gain, capacity gain or to overcome signal fading.

TABLE-I TRANSMISSION AND ENCODING SCHEME FOR 2X1 ALAMOUTI SCHEME

Time	antenna 1	antenna 2
t	s_1	s_2
$t+T$	$-s_2^*$	s_1^*

C. Forward Error Correction

Forward error correction (FEC) is a method of obtaining error control in data transmission in which the source (transmitter) sends redundant data and the destination (receiver) recognizes only the portion of the data that contains no apparent errors. The two main categories of FEC codes are BLOCK CODES and CONVOLUTIONAL CODES. Block codes work on fixed-size blocks (packets) of bits or symbols of predetermined size. Convolutional codes work on bit or symbol streams of arbitrary length. concatenated codes form a class of ERROR-CORRECTING CODES that are derived by combining an inner code and an outer code. The concatenated code is shown in fig.3.

Fig.3 CONCATENATED FEC BLOCK DIAGRAM

The Reed-Solomon encoding is mainly used to recover the main signal if it is distorted. The properties of Reed-Solomon codes make them suitable to applications, where errors occur in bursts. Reed-Solomon error correction is a coding scheme which works by first constructing a polynomial from the data symbols to be transmitted, and then sending an over sampled version of the polynomial instead of the original symbols themselves.

A Reed-Solomon code is specified as RS (n, k, t) with l-bit symbols. This means that the encoder takes k data symbols of l bits each and adds 2t parity symbols to construct an n-symbol codeword. The purpose of a convolutional encoder is to take a single or multi-bit input and generate a matrix of encoded outputs. One reason why this is important is that in digital modulation communications systems (such as wireless communication systems, etc.) noise and other external factors can alter bit sequences.

By adding additional bits we make bit error checking more successful and allow for more accurate transfers. By transmitting a greater number of bits than the original signal we introduce a certain redundancy that can be used to determine the original signal in the presence of an error.

After the RS encoding process, the data bits are further encoded by a binary convolutional encoder. It converts the single or multi bit into matrix form. It is used to discard noise from the main signal. It is another process of error correction.

D. Mimo - Ofdm

The block diagram of the MIMO-OFDM system is shown in the fig.4.In this paper, we have proposed a MIMO-OFDM based system employing the Forward Error Correction code which is the concatenated code. The paper is organised as follows. In the section II, we described the simulink model and in section III, simulation results are shown. The simulation of the proposed system by using the tool MATLAB simulink. The performance of the system is analysed over the rician and Rayleigh fading channel along with the AWGN channel.

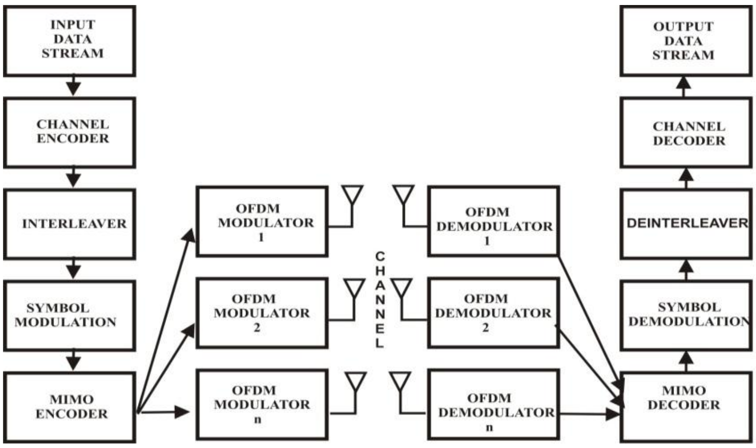


Fig.4 MIMO – OFDM SYSTEM BLOCK DIAGRAM

In spatial diversity a number of antennas are used to pick up the transmitted signals coming from different multipath fades. Say. You have M= 3 number of antennas in the transmitting side and have K (a1, a2, a3, a4, a5, a6) = 6 bits for sending. At first divide the bits into M=3 sub streams of data {(a1, a3), (a2, a4), (a3, a6)} and then multiply each sub stream of data with three carrier frequency in order to transmit them via three separate antennas. If all the sub-streams had to be transmitted by one carrier then the bandwidth consumptions would be three time greater-this is one of the great advantage of spatial multiplexing.

Now at the receiving end each sub-stream will have three spatial signatures-that means total 9 spatial signature will be at the receiving antenna-due to the multipath environment each sub stream will have its own spatial signature. Based on this spatial signature sub-streams of data will be demultiplexed and decoded in order to get back the original data stream.

II. SYSTEM MODEL

The system model consists of three sections Viz Transmitter, Channel, Receiver. The proposed MIMO-OFDM system using the concatenated codes is modeled in MATLAB using the SIMULINK. The simulink model of the proposed system is shown in the Fig.5.The parameters for the simulated system is shown in the TABLE.II

TABLE-II SIMULATION PARAMETERS

System parameters		
Simulink block	**Assigned parameters**	**Values**
Bernoulli Binary Generator	Probability of a zero	0.5
RS encoder	Code word length	255
Convolutional encoder	Trellis structure	poly2trellis(7, [171 133])
IFFT	Input port size	256
Rayleigh fading channel	Maximum Doppler shift	1/1000
AWGN channel	Mode	Signal to noise ratio(Es/N0)
Viterbi decoder	Trellis structure	poly2trellis(7, [171 133])
Signal to workspace	Variable name	BER

A. Transmitter

The proposed system uses the channel coding technique described in the section I.C.The encoding consists of the outer Reed Solomon Code and inner Convolutional code.The puncturing process is performed on the encoder output. The parameters of the encoder is based on the parameter in the table.I.

B. Channel

The 2X1 MIMO channel is constructed by using the fading channels along with the AWGN channel. The AWGN channel is used to simulate the background noise to the transmitted data. The fading channels used are Rician and Rayleigh fading channels. The channel model is shown in the fig.6.

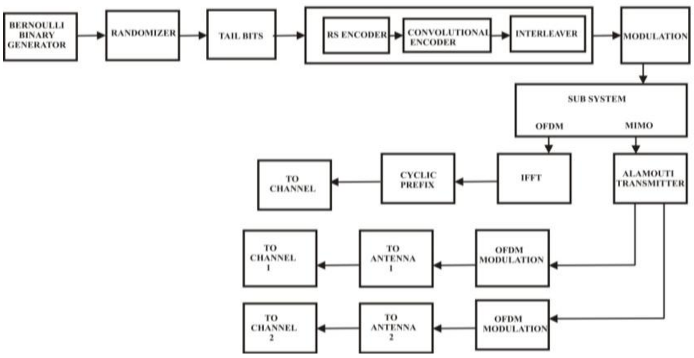


Fig.5 SIMULINK MODEL OF TRANSMITTER

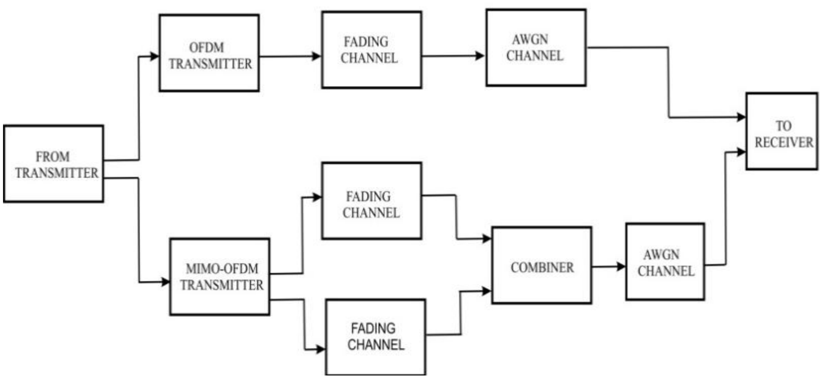


Fig.6 SIMULINK MODEL OF CHANNEL

C. Receiver

The channel decoder performs the inverse operation of the channel encoding section. The parameter are based on the one that was used in the encoding process. For the purpose of decoding the convolutional code, Viterbi decoder is used. The error rate is calculated by comparing the recovered data with that of the transmitted data.

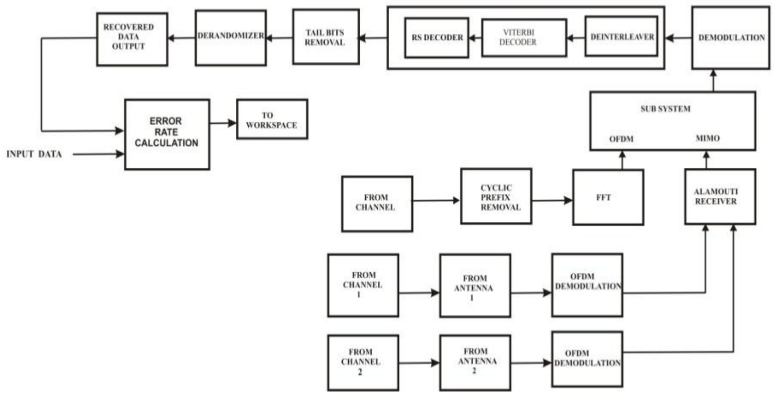


Fig.7 SIMULINK MODEL OF RECEIVER

III. Simulation Results

The MIMO-OFDM system with the concatenated FEC is simulated and the performance is evaluated over the Rician and Rayleigh fading channels. The BER was calculated and it was plotted by using the BERTOOL.fig.6 and fig.7 shows the simulation results for the system over the Rician and Rayleigh fading channels respectively.

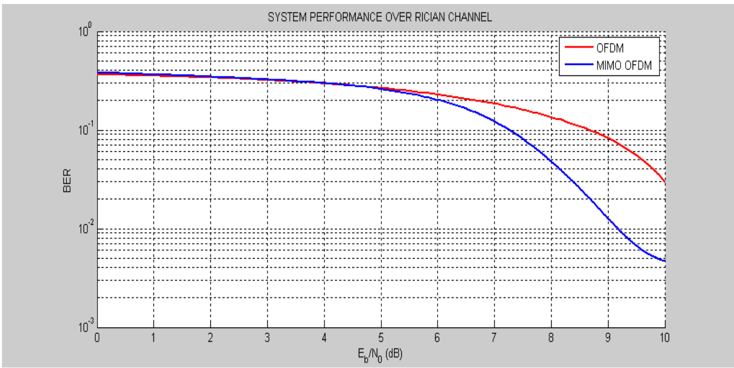


Fig.8 SYSTEM PERFORMANCE OVER RICIAN CHANNEL

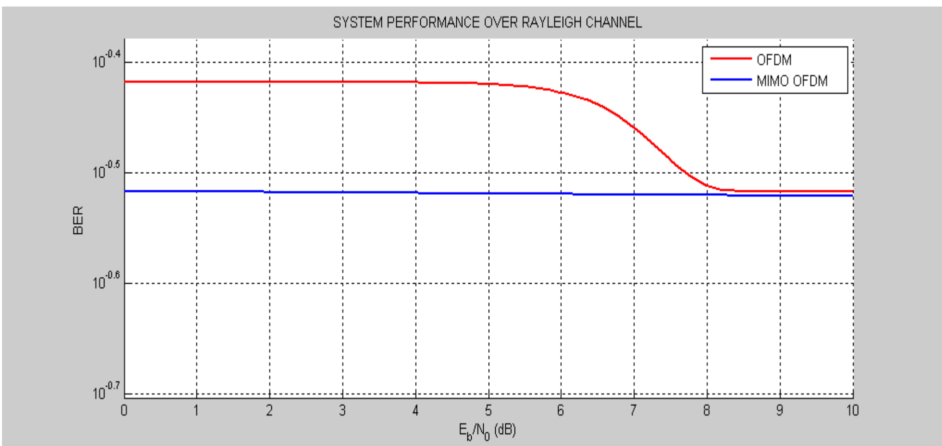


Fig.9 SYSTEM PERFORMANCE OVER RAYLEIGH CHANNEL

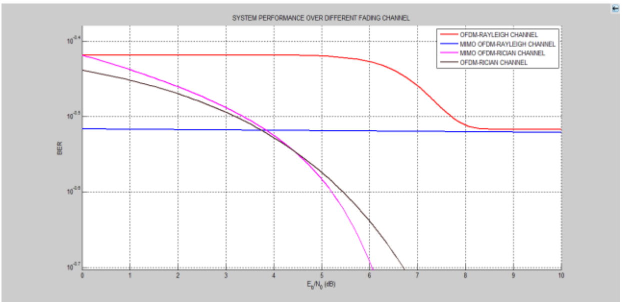


Fig.10 COMBINED RESULTS OF RICIAN AND RAYLEIGH CHANNELS

IV. CONCLUSION

The plot of BER Vs SNR is plotted in MATLAB by using the monte carlo simulation in BERTOOL. The BER is calculated by comparing the input data with that of the recovered data. The system is simulated over different ranges of SNR and the corresponding BER was calculated. From the results, it is clear that the BER of MIMO-OFDM system with concatenated FEC is better than the system using OFDM without having MIMO. Moreover, the performance of the system is better in the Rician fading channel.

References

[1]. R.Prasad, "Introduction" in *OFDM for Wireless Communications Systems*, London, United Kingdom: Artech House, 2004, pp. 11-14.
[2]. Implementation of MIMO-OFDM System, Muhammad Atif Gulzar, Rashid Nawaz , Devendra Thapa, Linnaeus university,2011
[3]. Implementation of a WiMAX simulation in Simulink by Amalia da Roca.
[4]. Coding for the Fading Channel: a Survey, Signal Processing for Multimedia, J.S. Byrnes (Ed.), IOS Press.
[5]. Simulation Study of Some Spatial Diversity Techniques for MIMO Wireless Communication Systems" International Journal of Emerging Technology and Advanced Engineering, Volume 2, Issue 12, December 2012.
[6]. "BER Comparison of Rayleigh Fading, Rician Fading and AWGN Channel using Chaotic Communication based MIMO-OFDM System" - Suchita Varade, Kishore Kulat, International Journal of Soft Computing and Engineering (IJSCE) ISSN: 2231-2307, Volume-1, Issue-6, January 2012.
[7]. "Concatenated Convolutional Codes for Deep Space Mission" Deepak Mishra, T.V.S Ram, K S Dasgupta & S.Jit International Journal of Information and Communication Technology Research , Volume 2 No. 6, June 2012 .
[8]. Bingham, J.A.C., Multicarrier Modulation for Data Transmission: IEEE Communications Magazine, Vol. 28, no.5, pp. 5-14, May 1990.
[9]. J.G. Proakis, Digital Communications, McGraw-Hill, 1987

Authors Profile

M. Prabakaran received his **M.E** degree in communication systems, Chennai, Anna University, Chennai, India in 2010 and the **B.E** degree in Electronics and Communication Engineering, Mannampandal, Anna University, Chennai, India, in 2007. Currently working as a **Assistant Professor** in Electronics and Communication Engineering department in Arasu Engineering college, Kumbakonam, India. His research interest includes wireless communication **(OFDM, MIMO)**, WiFi, WiMax, Communication Networks, Signal Processing, Sensor Networks, Mobile Ad hoc networks.

R. Rani kowsalya, doing her **B.E** degree in Electronics and communication Engineering, at Arasu Engineering college, Kumbakonam, Anna university Chennai. Her interesting areas are digital communication, **OFDM**, **MIMO**, Wireless Communication. Further, she is willing to pursue her career in telecommunication field.

C. Nithiya, doing her **B.E** degree in Electronics and communication Engineering, at Arasu Engineering college, Kumbakonam, Anna university Chennai. Her interesting areas are digital communication (**OFDM**), wireless communication (**MIMO**), signal processing. In future, she is interested to work in research environment related MIMO based communication system.