ISSN: 2278 – 909X
International Journal of Advanced Research in Electronics and Communication Engineering (IJARECE)
Volume 5, Issue 7, July 2016

Performance Analysis of Adaptive MIMO OFDM System

Mr. Bhavesh Khasdev , Mrs. Angeeta Hirwe

Abstract:— **The need of any communication system is high data speed with higher accuracy and reliability. Orthogonal Frequency Division Multiplexing (OFDM) provides optimistic solution for achieving high data rates in wireless environment. Orthogonal frequency division multiplexing (OFDM) is one of the multicarrier modulations, in which all of the sub channels are dedicated to a single data source In an OFDM transmission system, each subcarrier is attenuated individually under the frequency-selective and fast fading channel. If the same fixed transmission scheme is used for all OFDM subcarriers, it results in high attenuation and hence poor performance. Multiple input multiple output (MIMO) communication systems when integrated with the OFDM system can obtain high data rate transmission over broadband wireless channels. The purpose of this paper is to compare adaptive single input single output (ASISO) -OFDM with adaptive multiple input multiple output (AMIMO) -OFDM system and why MIMO is better than SISO is stated. Based on calculated average instantaneous signal to noise (SNR) same modulation scheme is applied to all subcarriers of same block. Average bit error rate (BER) performance of MIMO-OFDM system under fixed modulation and adaptive modulation is observed. The simulation results show that BER performance of MIMO OFDM system using adaptive modulation is better than fixed modulation**.

Keywords: OFDM, MIMO, FFT, IFFT, SIMO, MISO, SISO

I. INTRODUCTION

OFDM is a Multi-Carrier Modulation (MCM) scheme which converts a broadband frequency-selective channel into parallel flat-fading narrowband sub-channels. In a multipath environment, a transmitted symbol takes different time to reach the receiver through different propagation paths. From the receiver's point of view, the channel introduces time dispersion in which the duration of the received symbol is stretched. Extending the symbol duration causes the current received symbol to overlap previous received symbols and results in inter symbol interference (ISI). Cyclic Prefix (CP) is added to each symbol to mitigate the ISI (inter-symbol interference) caused by multipath wireless channel [1], and hence leads to spectral inefficiency. Cyclic prefix also causes ripples in the power spectral density (PSD) of the UWB (Ultra-Wideband) signal thus resulting in a transmit power back-off.

The implementation of Multiple-Input and Multiple-Output (MIMO) has dramatically improved the channel capacity performance of wireless communication system. MIMO systems are equipped with multiple number of antennas at both transmitter and receiver side to improve communication performance. MIMO offers a significant improvement in data throughput without additional bandwidth requirement. This is achieved by higher spectral efficiency and link diversity by reducing fading. Multiple Input Multiple Output (MIMO) and Orthogonal Frequency Division Multiplexing (OFDM) are the two assuring technologies that offers high data rate as required for the 4G wireless systems. Conventionally OFDM is Fast Fourier Transform (FFT) based system. It uses IFFT (Inverse FFT) blocks in the transmitter and FFT blocks in the receiver. OFDM combined with MIMO gives increased throughput and better system performance and hence FFT based MIMO OFDM systems are widely used in 4G wireless schemes.

TRANSMITTER designs adapted to the intended propagation channel are capable of improving both performance and rate of communication links. The resulting channel-adaptive transmissions adjust parameters such as power levels constellation sizes, coding schemes, and modulation types, depending on the channel state information (CSI) that is assumed available to the transmitter. The potential improvement increases considerably when multiple transmit and receive-antennas are deployed. However, as symbol rates increase in broadband wireless applications, the underlying multi-input multi-output (MIMO) channels exhibit strong frequency selectivity. By transforming frequency-selective channels to an equivalent set of frequency-flat sub channels, orthogonal frequency division multiplexing (OFDM) has emerged as an attractive transmission modality because it comes with low-complexity (de)modulation, equalization, and decoding to mitigate frequency-selective fading effects.

II. OFDM SYSTEM

Orthogonal frequency division multiplexing is a multicarrier transmission based on the principle of transmitting data by dividing the stream into several parallel bit streams, each of which has a lower bit rate, and by using several carriers called also subcarriers, to modulate these sub streams. This avoids the need to have non-overlapping subcarrier channels to eliminate inter-carrier interference. OFDM is being used in a number of wired and wireless voice and data application due to its flexible system architecture. The basic idea behind multi-tone modulation is to replace one wideband signal with many simultaneously transmitted narrowband signals with the same overall bandwidth as the original signal. To implement OFDM transmitters and receivers in discrete time, Inverse fast Fourier transform (IFFT) and Fast Fourier transform (FFT) are used respectively.

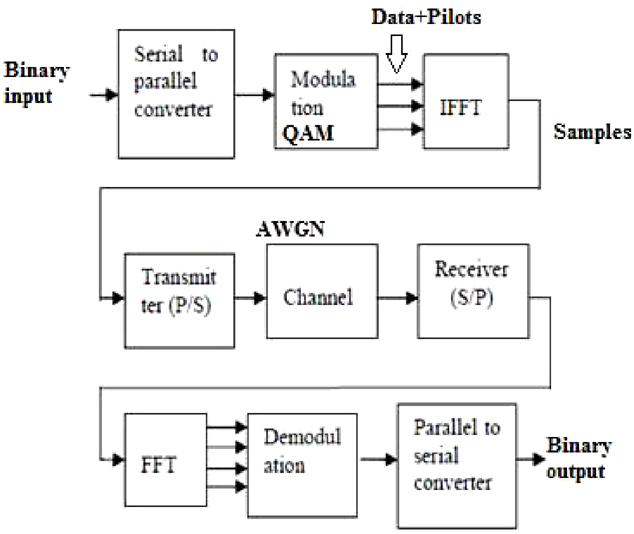


Figure 1. Basic OFDM system

Fig. 1 shows the basic block diagram of an OFDM system. The main concept of OFDM is the Orthogonality of subcarriers. OFDM transmits symbols that have long time duration, which is less or equal to the maximum delay spread. To eliminate ISI, guard intervals are used between OFDM symbols.

III. COMPARISION

A. Comparison of SISO, SIMO and MIMO system:

A MIMO communication system executes an average error probability that decays as where'd' is the diversity gain and is based on the assumption that at least one of the paths will not be in a deep fade state. Another advantage of a MIMO system is that, it is said to achieve multiplexing gain r, and the achievable rates scale as [r log (SNR)]. The multiplexing gain (unique for MIMO systems) is defined as the increase of the rate that can be attained through the use of multiple antennas at both sides of communication links, with respect to the rate achievable with single antenna system, without utilizing additional power.

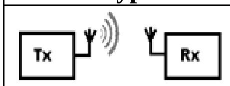
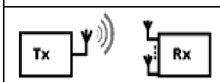
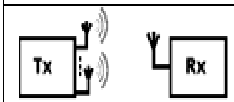
Type	Advantage	Disadvantage
 SISO	• Simplicity • No additional Processing required	• Interference • Fading
 SIMO	• Easy to implement	• Additional Processing Required
 MISO	• Processing redundancy moved from receiver to transmitter	• Additional Processing Required

Table 1 : Comparison of SISO, SIMO and MISO

B. Comparison of SISO and MIMO system:

The simplest form of radio link can be defined as SISO - Single Input Single Output as shown in figure 2. This is effectively a standard radio channel - this transmitter operates with one antenna as does the receiver

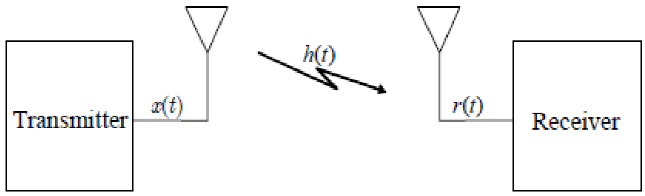


Figure 2. SISO SYSTEM

The advantage of a SISO system is its simplicity. The SISO channel is limited in its performance. Interference and fading will impact the system more than a MIMO system using some form of diversity, and the channel bandwidth is limited by Shannon's law the throughput being dependent upon the channel bandwidth and the signal to noise ratio.

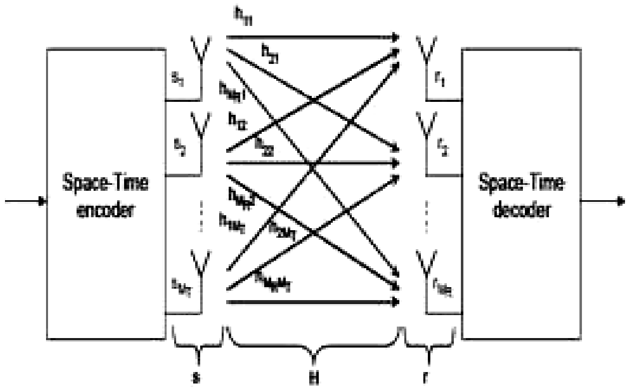


Figure 3. MIMO system

Figure 3 show block diagram of the MIMO system which consists of space time block code and spatial multiplexing which are explained as follows.

Space-Time Block Codes: Space-Time Block Codes (STBCs) are the simplest of spatial temporal codes that exploit the diversity offered in systems with several transmit antennas. The transmit diversity technique proposed by Alamouti was the first STBC.The encoding and decoding operation is carried out in sets of two modulated symbols. They are S_1 and S_2 the two modulated symbols that enter the space-time encoder. In the Alamouti scheme, during the first time instance t, the symbols S_1 and S_2 are transmitted by the first and the second antenna element, respectively. During the second time instance t_1, the negative of the conjugate of the second symbol, i. e. $-S_1^*$ is sent to the first antenna while the conjugate of the first constellation point. i. e. S_2^* is transmitted from the second antenna. The transmission rate is equal to the transmission rate of a SISO system. The space-time encoding mapping of Alamouti 2x2 can be represented by the coding matrix

$$S = \begin{bmatrix} s_1 & s_2 \\ s_2 & s_1 \end{bmatrix} \text{..............(1)}$$

The received signals at the time t and t + T can then be expressed as:

$$r_1 = r_1(t) = h_{11}s_1 + h_{21}s_2 + n_1$$

$$r_2 = r_1(t+T) = -h_{11}s_2^* + h_{21}s_2^* + n_2$$

$$r_3 = r_2(t) = h_{12}s_1 + h_{22}s_2 + n_3 \text{ .... (2)}$$

$$r_4 = r_2(t+T) = -h_{12}s_2^* + h_{22}s_2^* + n_4$$

Where r_1 , r_3 are the received signals at time t and r_2 , r_4 are the received signals at time t+T ,n1,n2,n3 and n4 are complex random variables representing receiver noise and interference. This can be written in matrix form as:

$$r = HS + n \qquad \text{............(3)}$$

where H is the complex channel vector and n is the noise vector at the receiver.

2) Spatial Multiplexing: In spatial multiplexing, a signal is divided into different streams and each stream is transmitted from a different transmit antenna in the same frequency channel. If these signals arrive at the receiver antenna array with sufficiently different spatial signatures, the receiver canseparate these streams, creating parallel channels for free. Spatial multiplexing is very powerful technique for increasing channel capacity at higher Signal to Noise Ratio (SNR). It can be used with or without transmit channel knowledge. Consider that we have a transmission sequence, for example S_1, S_2,……S_n For 2 transmit antennas, the symbols are group into groups of two. In the first time slot, Signal S_1 and S_2 from the first and second antenna are send . In second time slot, signal S_3 and S_4 from the first and second antenna are send. Two symbols and are grouped together and send them in one time slot, but only n /2 time slots to complete the transmission, so data is doubled. Transmission for 2 x 2 MIMO systems can be represented in matrix notation as follows:

$$\begin{bmatrix} y_1 \\ y_2^* \end{bmatrix} = \begin{bmatrix} h_1 & h_2 \\ \tilde{h}_2^* & -\tilde{h}_1^* \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} n_1 \\ n_2^* \end{bmatrix}$$

IV. MIMO–OFDM TRANSMISSION SCHEME

The OFDM is a special type of frequency division multiplexing (FDM) wherein signals are not multiplied by a single carrier. If the FDM System had been able to use a set of subcarriers that were orthogonal to each other, a higher level of spectral efficiency could have been achieved. The guard bands that were necessary to allow individual demodulation of subcarriers in an FDM system would no longer be necessary. The use of orthogonal sub-carriers would allow the sub-carriers spectra to overlap, thus increasing the spectral efficiency. As long as orthogonality is maintained, it is still possible to recover the individual sub-carriers signals despite their overlapping spectrums. If the dot product of two deterministic signals is equal to zero, these signals are said to be orthogonal to each other. Orthogonality can also be viewed from the standpoint of stochastic processes. If two random processes are uncorrelated, then they are orthogonal. Each sub-set of carrier creates a sub-channel for communication.
The advantages are

(i) They are less prone to interference, since each sub-carrier frequency is kept orthogonal to one another.
(ii) Huge bandwidth efficiency due to reduced carrier spacing (orthogonal carriers overlap)
(iii) Simple Equalization scheme or no equalization scheme
(iv) Resistant to fading
(v) Scalable data transfer rate in different channel conditions
(vi) Single Frequency Networks are possible (broadcast application)

The block diagram of the MIMO-OFDM transmission scheme is shown in figure 4. In practice, OFDM systems are implemented using a combination of fast Fourier transform (FFT) and inverse fast Fourier transform(IFFT) blocks that are mathematically equivalent versions of the DFT and IDFT, respectively, but more efficient to implement. An OFDM systems treats in source symbols (e.g., the QPSK or QAM symbols that would be present in a single carrier system) at the transmitter as though they are in the frequency domain. These symbols are used as inputs to the IFFT block that brings the signal into the time domain. The IFFT takes in N symbols at a time where N is the number of subcarriers in the system. Each of these N input symbols has a symbol period of T seconds. Recall that the basis functions for an IFFT are N orthogonal sinusoids. These sinusoids have a different frequency and the lowest frequency is DC. Each input symbol acts like a complex weight for the corresponding sinusoidal basis function. Since the input symbols are complex, the value of the symbol determines both the amplitude and phase of the sinusoid for the subcarrier. The IFFT output is the summation of all N sinusoids. Thus the IFFT block provides a simple way to modulate data on to N orthogonal sub-carriers.

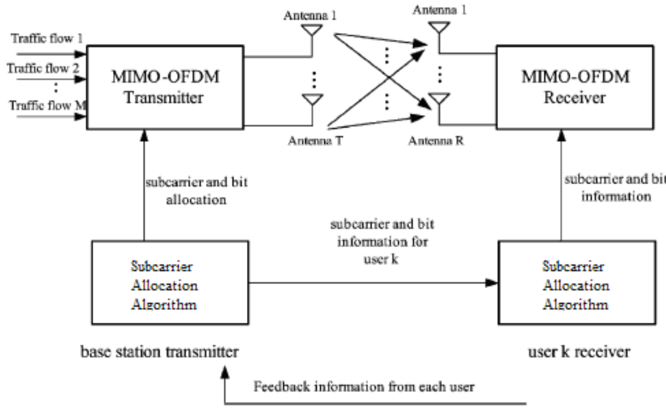


Figure 4: Block diagram of multiple antenna OFDM multicast system

ISSN: 2278 – 909X
International Journal of Advanced Research in Electronics and Communication Engineering (IJARECE)
Volume 5, Issue 7, July 2016

V. ADAPTIVE MODULATION ALGORITHM

In this paper, sub band adaptive transmission schemes are employed to reduce the complexity. In this simulation the instantaneous SNR of the subcarrier is measured at the receiver. The channels quality varies across the different subcarriers for frequency selective channels. The received signal at any subcarrier can be expressed as:

$$Rn = HnXn + Wn \qquad \text{.........................(5)}$$

Where the **Rn** channel coefficient at any subcarrier is, **Xn** is the transmitted symbol and is the **Wn** Gaussian noise sample. So the instantaneous SNR can be calculated using

$$SNRn = \frac{Hn^2}{N0} \qquad \text{........................ (6)}$$

Where **N0** is the noise variance.

The Adaptive algorithm used in this paper is used to provide a better tradeoff between throughput and overall BER by choosing a more suitable scheme for both sub band. Instead of using the lowest SNR in both sub band, the average value of the SNR of the subcarriers in the sub band is going to be used.

A.Channel Quality Estimation

Adaptive modulation requires that the transmitter knows channel state information. This requirement sounds trivial, but is quite difficult to realize in practice. It requires the channel to be reciprocal- e.g. the Base station learns the channel state while it is in receiving mode; when it then transmits, it relies on the fact that the channels is still in the same state. This can only fulfilled in the system with Time Domain Duplexing (TDD) in slowly time-varying channels. Alternatively, feedback from the receiver to transmitter can be used. It is also noteworthy that the transmitter has to know the channel-state information for the time instant when it will transmit. Channel prediction is thus an important component for many adaptive modulation systems.

B. Parameter Adaption:

Once the channel state is known, the transmitter has to decide how to select the correct transmission parameter for each subcarrier- namely coding rate and modulation alphabet. Furthermore, we also have to consider how much power should be assigned to each channel.

VI. SYSTEM MODEL

Figure 5 demonstrates the implementation of MIMO in OFDM system, data is generated from random generator, and random generator will produce 192 samples per frame. Also modulation i.e M-ary number will be generated here, then this signal will go to integer to bit convertor which will convert continues signal into discrete signal. Then this signal will send to Rectangular QAM Modulator which will map the signal according to M ary number. This signal will go to OFDM block, here subcarrier signal ,cyclic prefix, pilots, null vector ,FFT size all this parameter calculated here, then this signal will give to OSTBC Encoder, here Number of transmit antennas will be decided , also in no of antennas are more than 2 then code rate is also decided here.

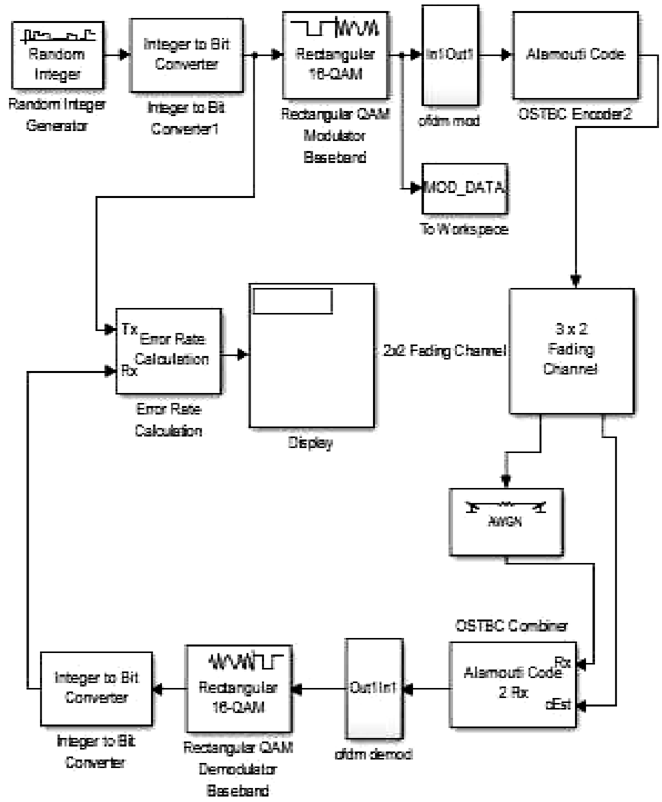


Figure 5 .MIMO-OFDM SYSTEM

VII. SIMULATION RESULTS

CSNR	MODULATION SCHEME	CODING RATE	BER	FAULT BITS
6.4 TO 9.4	BPSK	1/2	$2.584e^{-006}$	81
9.5 TO 11.2	QPSK	1/2	$2.076e^{-007}$	17
11.3 TO 12	**QPSK**	**3/4**	$2.167e^{-007}$	**27**
12.1 TO 18	**16 QAM**	**1/2**	$2.391e^{-007}$	**40**
18.1 TO 22.6	**16 QAM**	**3/4**	$2.176e^{-007}$	**55**
22.7 TO 24.4	**64 QAM**	**2/3**	$3.798e^{-007}$	**257**
24.5 TO 50	**64 QAM**	**3/4**	0.0002367	$9.01e^{04}$

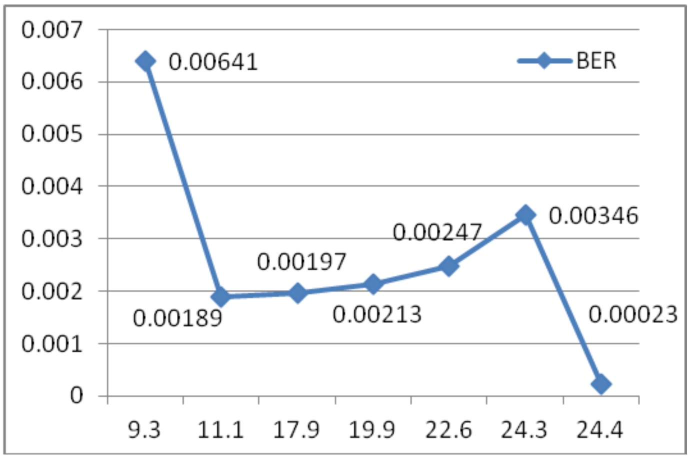


Figure 6. *BER vs CSNR of Adaptive MIMO OFDM*

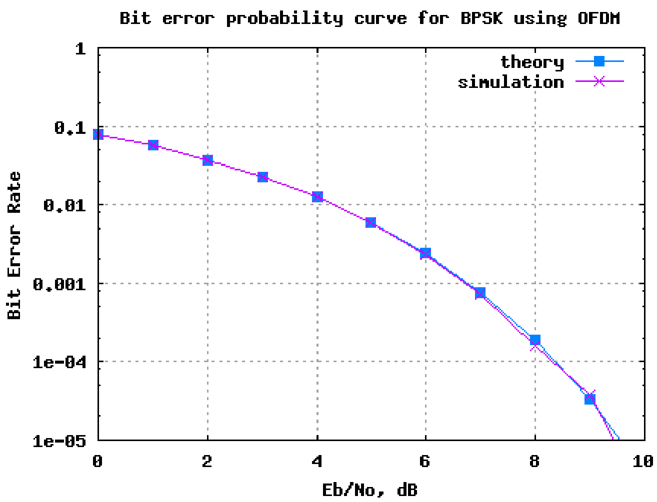


Figure7. BER performance of BPSK

VIII. CONCLUSION

Adaptive modulation schemes for the both subcarriers in an OFDM transmission system with MIMO and SISO are describe in this paper. The bit error ratio transmitted signal in MIMO system is gradually less than SISO system. Simulations show that for a bit error ratio of and a signal to noise ratio of 4 to **8** dB can be achieved In adaptive modulation, modulation rate changes based upon value of an instantaneous SNR. The BER performance comparison between fixed and adaptive modulation shows that BER performance for Adaptive modulation techniques is better than all other modulation technique's.

IX. REFERENCES

[1] Peng Xu, Jiangzhou Wang, " Analysis and Design of Channel Estimation in Multicell Multiuser MIMO OFDM Systems", *IEEE Transactions on Vehicular Technology*, Vol..64,No.2,February 2015.

[2] Ki-Doo Kim, Md. Mejbaul Haque, Md. Shaifur Rahman, " *International Journal of Multimedia and Ubiquitous Engineering*", Vol.8, No.1, January 2013.

[3] Xiuyan Zhang, Yajie Su, Guobin Tao, " *2010 3rd International Congress on Image and Signal Processing* (CISP 2010).

[4] J.Faezah, K.Sabira]-"Adaptive modulation with OFDM system"- International Journal of communication Networks and Information Security- Vol. 1, No. 2, August 2009.

[5] A.Sohail and M.N.Jafri, "Adaptive OFDM over Frequency Selective and Fast Fading Channel Using Blockwise Bit Loading Algorithm", *IEEE International Conferenece on Wireless and Optical CommunicationNetworks*,pp. 1-4, July 2007.

[6] K. K. Wong, R. D. Murch and K. B. Letaief, "Performance enhancement of multiuser MIMO wireless communication systems", *IEEE Transactions on Communications*, vol. 50, (2002) December. 1960- 1970.
.

Bhavesh khasdev, Student of Master of Engineering in Digital Communication From IES IPS Academy Indore & Received Bachelor of Engineering in ECE from RGPV Bhopal in 2011.

Angeeta Hirwe, Asst. Professor in Department of Electronics and Communication Engineering IES IPS Academy Indore, received M.E. from DAVV Indore.