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ANALYSIS OF BER AND SEP OF QPSK SIGNAL FOR MULTIPLE ANENNAS

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Abstract—This paper presents a Performance Analysis of Multiple Input Multiple Output (MIMO) Orthogonal Frequency Division Multiplexing (OFDM) for multiple antennas combined with Orthogonal Space Time Block Codes (OSTBC). MIMO uses multiple antennas at both transmitter and receiver side. OFDM is one of the best digital modulation schemes, where spectrum is divided into number of narrow band channels to obtain spectral efficiency and minimizing the Inter Symbol Interference (ISI) and Inter Carrier Interference (ICI). The Performance is calculated in terms of Bit Error Rate (BER) and Symbol Error Probability (SEP) versus the Signal to Noise Ratio (SNR) for the Quadrature Phase Shift Keying Signal (QPSK) for multiple antennas (4x4) MIMO,(8x8) MIMO and (16x16) MIMO.

Index terms: MIMO-OFDM, Orthogonal STBC, Error Rate, QPSK Signal .

I. INTRODUCTION

The combination of multiple input multiple output (MIMO) and orthogonal frequency division multiplexing (OFDM) is an attractive technology approach for communications systems, [1]. MIMO-OFDM is the dominant air interface for 4G and 5G broadband wireless communications. Wireless communication can be regarded as the most significant and important development in modern society. It need tremendously high data rates and high transmission reliability in order to meet the increasing demand for multimedia applications.

All wireless technology face the challenges of fading effect, interference and low spectrum. Orthogonal Frequency Division Multiplexing (OFDM) plays a important role and reduce receiver complexity in wireless systems but in this case synchronization and channel estimation are very important, and it is replaced by Multiple Input Multiple Output-Orthogonal Frequency Division Multiplexing (MIMO-OFDM) which a multi user system that allows multiple access that combines Time Division Multiplexing (TDM) and Frequency Division Multiplexing (FDM) on the same channel. OFDM is a widespread and beneficial in many areas such as high spectral efficiency, robustness, low computational complexity, frequency selective fading.

Recently, there have been a lot of interest to use OFDM in combination with a MIMO transceiver system which is used to increase the diversity gain and system capacity. It is motivated for two vital goals: high-data-rate and high performance, usually fading is problem in wireless network but MIMO channels uses the fading to increase the capacity of entire communication network. MIMO-OFDM which is widely used for the next generation wireless communication systems such as WLAN, WMAN and WiMAX.

In this paper, we simulate and compare the BER and SEP Performance of STBC OFDM system using QPSK schemes for (4x4) MIMO, (8x8) MIMO and (16x16) MIMO antenna schemes over Additive White Gaussian Noise (AWGN) Channels. The combination of STBC and OFDM provides double Orthogonality to the transmitting signal and improves security during transmission of data

II. MIMO-OFDM

MIMO-OFDM is the foundation for most advanced wireless local area network and mobile broadband network standards because it achieves the greatest spectral efficiency and therefore, delivers the highest capacity and data throughput. Therefore MIMO-OFDM produced by employing multiple transmit and receive antennas in an OFDM system has becoming a practical alternative to single carrier and Single Input Single Output (SISO) transmission.

However channel estimation becomes computationally more complex compared to the SISO systems due to the increased number of channels to be estimated. This complexity problem is further compounded when the channel from the i_{th} transmit antenna to the m_{th} receive antenna is frequency selective. Using OFDM, information symbols are transmitted over several parallel independent sub-carriers using the computationally efficient Inverse Fast Fourier

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Transform (IFFT) / Fast Fourier Transform (FFT) modulation/demodulation vector.

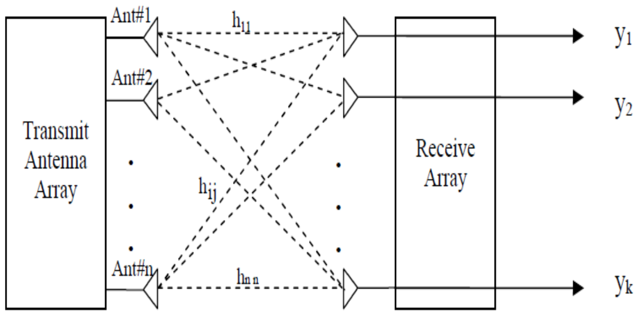

Fig.1. Block diagram of multiple transmit and receive antennas

MIMO-OFDM indicates the presence of multiple transmit antennas (multiple input) and multiple receive antennas (multiple output). While multiple transmit antennas can be used for beam forming, and multiple receive antennas can be used for diversity. Space-time codes are employed to ensure that the signals transmitted over the different antennas are orthogonal to each other, making it easier for the receiver to distinguish one from another. OFDM enables reliable broadband communications by distributing user data across a number of closely spaced, narrowband subchannels.

This arrangement makes it possible to eliminate the biggest obstacle to reliable broadband communication, intersymbol interference (ISI). These MIMO wireless systems, combined with OFDM, have allowed for the easy transmission of symbols in time, space and frequency. In order to extract diversity from the channels, different coding schemes have been developed. The seminal example is Alamouti Space Time Block Code (ASTBC), Orthogonal Space Time Block Code (OSTBC) and Quasi Space Time Block Code (QSTBC).

MIMO-OFDM is a particularly powerful combination because MIMO does not attempt to mitigate multipath propagation and OFDM avoids the need for signal equalization. MIMO-OFDM can achieve very high spectral efficiency even when the transmitter does not possess channel state information (CSI). When the transmitter does possess CSI (which can be obtained through the use of training sequences), it is possible to approach the theorectical channel capacity. CSI may be used, for example to allocate different size signal constellations to the individual subcarriers, making optimal use of the communications channel at any given moment of time.

III. EXPERIMENAL DESIGN OF OFDM TRANSCEIVER

Proposed technique for designing OFDM transceiver is to reduce the error rate by increasing the antennas at both transmitter and receiver side. The block system is divided into 3 mains sections namely Transmitter, Channel and the Receiver.

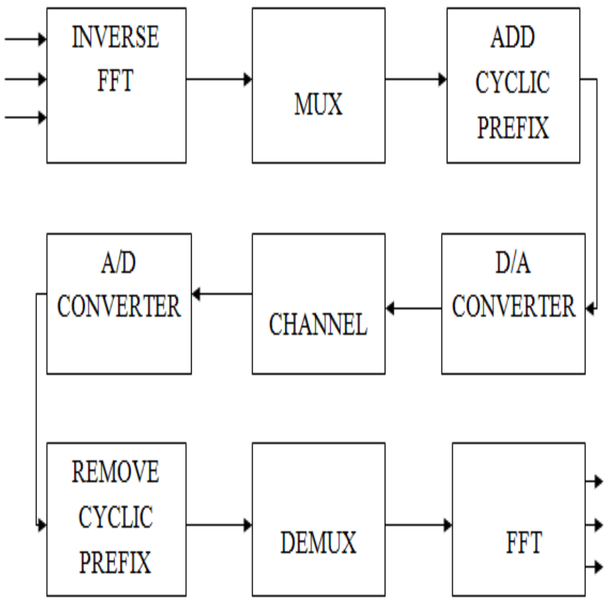

Fig. 2. Block diagram of OFDM transceiver

Dividing the spectrum in to many narrow band carrier and subcarrier and dividing spectrum is done in order to get an high spectral efficiency and this the frequency response of subcarrier are orthogonal to each other and hence the name called Orthogonal Frequency Division Multiplexing (OFDM). In this the signals are modulated using many ways but the common used methods are Binary Phase Shift keying (BPSK) signal, Quadrature phase shift keying (QPSK) signal and Quadrature Amplitude Modulation (QAM). The length of the time for OFDM is equal to the reciprocal of spacing between the subcarrier.

$$M = N \times B$$

M- Bits are encoded in frequency domain.

N- No of subcarriers.

B- No of bits per modulation.

For QPSK modulation B=2.

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A. Transmitter

OFDM signals are generated digitally and the signals consists of a sum of subcarriers that are modulated using QPSK. The relationship between all the carriers must be controlled to maintain the orthogonality of the carriers. After modulating the input data digitally, the resulting spectrum is converted back to its time domain using Inverse Fourier Transform (IFFT) and then these signals are combined and then transmitted. An IFFT drastically reduce the amount of calculations by exploiting the regularity of operations.

One of the most important advantages of OFDM is its robust to multipath delay spread, and that is achieved by dividing the input in Ns subcarrier. Cyclic prefix (CP) is introduced to each symbol to eliminate ISI. Inter Symbol Interference (ISI) occurs when the overlap between consecutive symbols is large compared to the symbols duration. Normally, high data rates require shorter duration symbols, increasing the risk of ISI. By dividing a high-rate data stream into numerous low-rate data streams, OFDM enables longer duration symbols. A cyclic prefix may be inserted to create a guard interval that prevents ISI entirely. If the guard intervals is longer than the delay spread-the difference in delays experienced by symbols transmitted over the channel-then there will be no overlap between adjacent symbols and consequently no ISI.

Cyclic prefix is often used in conjunction with modulation in order to retain sinusoidal properties in a multipath channel. It is well know that sinusoidal signal have eigen function of linear and time invariant system. Therefore the channel is assumed to be linear and time invariant then a sinusoidal of infinite duration would be an eigen function. But in practice it cannot be achieved as real signals are always time limited to minimize the infinite behavior prefixing the end of the symbol to the beginning makes linear convolution of the channel appear as though it were circular convolution and then preserve this property in the most of the symbol after cyclic prefix.

Another problem associated with is Inter Carrier Interference (ICI). ICI is the cross talk between different subcarriers, which mean they are no longer orthogonal. To eliminate ICI, OFDM symbol must be cyclically extended in the guard time. This ensures that the delayed replicas of the OFDM symbol always have an integer number of cycles with in FFT interval, as long as the delay is smaller than the guard time. As a result, all multipath signals with delay smaller than the guard time cannot cause ICI

B. Channel

We choose the most widely used channels is Additive White Gaussian Noise (AWGN) channel. AWGN channel is a basic or commonly used channel model for analyzing modulation schemes. In this model, the AWGN channel adds a White Gaussian noise to the signal that passes through it. This implies that the channel's amplitude frequency response is flat and phase frequency response is linear for all frequencies so that modulated signals go through it without any amplitude loss and phase distortion. Fading does not exist for this channel. The transmitted signal gets disorted only by AWGN process. AWGN channel is a standard channel used for analysis purpose only.

The mathematical expression in receiving signal is:

$$r(t) = s(t) + n(t)$$

That passes through the AWGN channel where,

s(t) = Transmitted Signal

n(t) = Background noise or Additive White Gaussian Noise

r(t) = Received signal

C. Receiver

The transmitted signal is received and then cyclic prefix has been removed. The demodulation of an OFDM signal is performed exactly the same manner. In the receiver, Fast Fourier Transform (FFT) is used to estimate the amplitude and phase of each subcarrier. The FFT performs the same operations as the matched receiver for the single carrier transmission, expect for a bank of subcarriers. The first task performed at the receiver is removal of cyclic prefix. This eliminates the inter symbol interference (ISI). A key advantage of OFDM is that Fast Fourier Transform (FFT). FFT convert signals back and forth between the time domain and frequency domain.

FFT also enable OFDM to make efficient use of bandwidth. The sub-channels must be spaced apart in frequency just enough to ensure that their time-domain waveforms are orthogonal to each other. In practice, this means that the sub-channels are allowed to partially overlap in frequency. Then de-multiplexer is used where signals are separated to their corresponding subcarrier frequency. Then FFT is performed in order to get an time domain in to frequency domain.

The signal was found distorted by the channel, however to reconstruct the original signal, the information on how these channels are acted on the transmitted signal need to be obtained to mitigate its effect. This is called equalization. In OFDM system, this is done by channel estimation and interpolation, and reverse process (including decoding) is executed to obtain the original data bits.

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IV. ORTHOGONAL SPACE TIME BLOCK CODES

Orthogonal Space Time Block Codes (OSTBC) are designed for more than two antennas. OSTBC mean the frequency in the sub carrier should be orthogonal to each other. Space time block coding is a technique used to improve the performance of a wireless transmission system, where the receiver is provided with multiple signals carrying the same information. The concept behind space time block coding is to transmit multiple copies of the same data through multiple antennas in order to improve the reliability of the data-transfer through the noisy channel. OSTBC achieve full diversity order, in the receiver terminal, space time coding combines together all the copies of the received signal in an optimal way to extract as much information from each of them as possible.

OSTBC retains the property of having linear maximum-likelihood decoding with full transmit diversity at low computational cost. It suffers a loss in capacity when there are multiple receive antennas and the code rate is less than one. As rate-1-OSTBC with complex constellation is not possible for more than two transmit antennas will always suffer capacity loss.

V. SIMULATION AND RESULT

The Performance of this system is calculated with reference to SEP v/s SNR and BER v/s SNR.

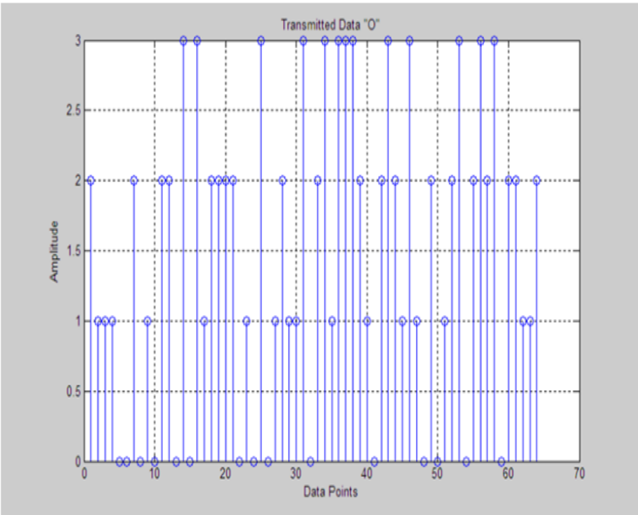

Fig. 3. Input image of MIMO-OFDM system

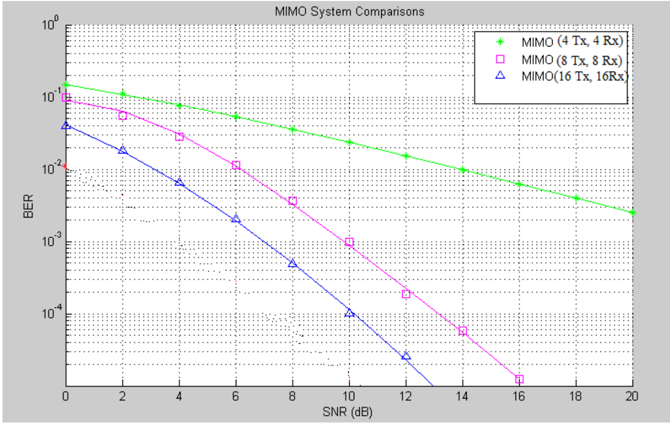

Fig. 4. BER vs SNR comparison for multiple antennas

As observed from the above figure that BER of 4 user MIMO requires around 20db, where as 8 user MIMO require 16db and 16 user MIMO require only 13 db and it can be observed that BER is reduced by increasing the transmitting and receiving antennas.

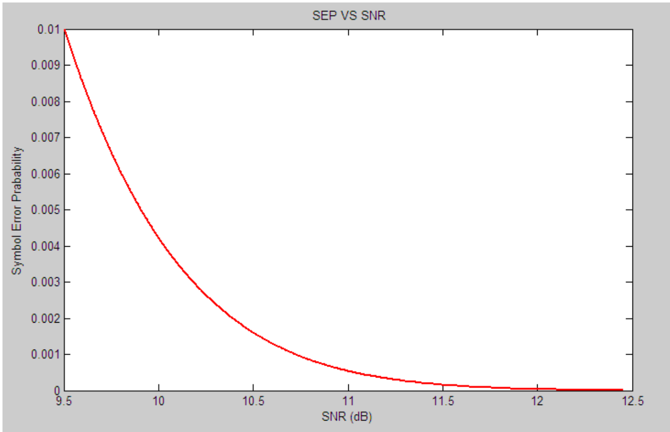

Fig. 5. SEP vs SNR for MIMO system

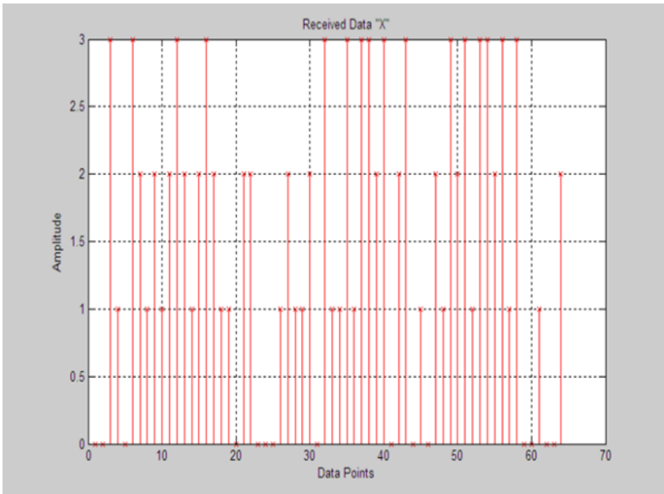

Fig 6. Output image of MIMO-OFDM

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V. CONCLUSION

This paper demonstrates the result of MIMO (4x4), MIMO (8x8) and MIMO (16x16) with digital data input. The result shows that SEP and BER is reduced for MIMO (16x16) system as compared to MIMO (8x8) and MIMO (4x4) system. By increasing the antenna at both transmitter and receiver side leads to increase the performance of the system, improve the signal quality and also reduce the effect of fading. So MIMO-OFDM system can communicate reliably at the low values of SNR. It is also used for multimedia application and high speed internet applications in low Signal to Noise Ratio (SNR) areas.

References

1. Banelli P. and Cacopardi S.(2010), "Theoretical analysis and performance of OFDM signals in nonlinear AWGN channels," *IEEE Trans. Comm*.,vol. 48, no. 3, pp. 430–441.
2. Chen B. Yang C. and Liao W.(2012), "Robust fast time-varying multipath fading channel estimation and equalization for MIMO-OFDM systems via a fuzzy method," *IEEE Trans. Veh. Technol*., vol. 61, no. 4, pp.1599–1609.
3. Droma M.O. and Lei Y.(2013), "A new Bessel-Fourier memoryless nonlinear power amplifier behavioural model," *IEEE Micro. Wireless Comp*.,vol. 23, no. 1, pp. 25–27.
4. Droma M.O.(2011), "Dynamic range and other fundamentals of the complex Bessel function series approximation model for memoryless nonlinear devices," *IEEE Trans. Commun*., vol. 37, no. 4, pp. 397–398.
5. Droma M.O. and Ganchev I.(2010), "The creation of a ubiquitous consumer wireless world through strategic ITU-T standardization," *IEEE Commun. Mag.*, vol. 48, no. 10, pp. 158–165.
6. Drotar P. Gazda J. Galajda P. Kocur D. and Pavelka P.(2010), "Receiver technique for iterative estimation and cancellation of nonlinear distortion in MIMO SFBC-OFDM systems," *IEEE Trans. Consum. Electron*., vol. 56, no. 2, pp. 471–475.
7. Hemesi H. Abdipour A. and Mohammadi A.(2013), "Analytical modeling of MIMO-OFDM system in the presence of nonlinear power amplifier with memory," *IEEE Trans. Commun.*, vol. 61, no. 1, pp. 155–163.
8. Kim H.S. and Daneshrad B.(2011), "Power optimized PA clipping for MIMOOFDM systems," *IEEE Trans. Wireless Commun*., vol. 10, no. 9, pp. 2823–2828.
9. Larsson E.G. and Stoica P.(2010), Space-Time Block Coding for Wireless Communications. *Cambridge University Press.*
10. Lei Y. and Droma M.O.(2011), "Behavioural analysis of internal mechanism of nonlinear distortion in OFDM signal systems," *IEEE Global Comm. Conf.*
11. Maaref A. and Aissa S.(2011), "Capacity of space-time block codes in MIMO Rayleigh fading channels with adaptive transmission and estimation errors," *IEEE Trans. Wireless Commun.*, vol. 4, no. 5, pp. 2568–2578.
12. Qi J. and Aissa S.(2010), "Analysis and compensation of power amplifier nonlinearity in MIMO transmit diversity systems," *IEEE Trans. Veh. Technol*, vol. 59, no. 6, pp. 2921–2931.
13. Shin H.D. and Lee J.H.(2004), "Performance analysis of space-time block codes over keyhole Nakagami-m fading channels," *IEEE Trans. Veh. Technol.*, vol. 53, no. 2, pp. 351–362.
14. Telatar E.(2010) "Capacity of the multiple antenna Gaussian channel," *Euro. Trans. Telecomm.*, vol. 10, no. 6, pp. 585–595.
15. Van den Bos C. Kouwenhoven M.H.L. and Serdijn W.A. (2012), "Effect of smooth nonlinear distortion on OFDM symbol error rate," *IEEE Trans. Commun.*, vol. 49, no. 9, pp. 1510–1514.

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