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Performance Analysis of PAPR in STBC MIMO-OFDM System under Different Modulation Schemes

P. Vidyullatha[1], R. Chandrasekhar[2], K. Rushendra Babu[3], B. Ajay Kumar[4]

PG Student [DECS], Dept. of ECE, Gudlavalleru Engineering College, Gudlavalleru, India[1]

Assistant Professor, Dept. of ECE, Gudlavalleru Engineering College, Gudlavalleru, India[2, 3, 4]

ABSTRACT: Orthogonal frequency division multiplexing (OFDM) is a best method for encoding digital data on multiple carriers. The carriers are different frequencies and are orthogonal to each other. Orthogonality in OFDM reduces bandwidth usage and frequency selective fading due to multipath. The motivation behind MIMO is its data rate. MIMO provides enormous data rate and improves bit error rate. Data rate is provided by spatial multiplexing technique and bit error rate is improved by space diversity technique. Space time block coding (STBC) is a technique in MIMO which provides space diversity. The combination of both MIMO and OFDM namely Multiple-input multiple-output orthogonal frequency division multiplexing (MIMO-OFDM) is a hopeful technology for high data rate transmission in wireless communication. Peak to average power ratio (PAPR) is the main problem which occurs in MIMO-OFDM system and causes signal distortions and increases complexity in A-D and D-A. In this paper PAPR and BER values are calculated and analysis is done for MIMO-OFDM under Binary phase shift keying (BPSK), Quadrature phase shift keying (QPSK), and Quadrature amplitude modulation (16-QAM) schemes.

KEYWORDS*:* MIMO, OFDM, STBC.

I. INTRODUCTION

New technologies are emerged in wireless systems. The next generation mobile systems are expected to provide a high data rate to meet the requirements of future high performance multimedia applications. Initially in a system, generally the total information is send through single carrier. A single carrier system modulates information onto one carrier using frequency, phase or amplitude [1]. This system faces information loss from signal reflections, impulse noise and other impairments. Frequency division multiplexing (FDM) is an extension of single carrier modulation by using multiple sub carriers in the same single channel. Frequency division multiplexing is a form of multiplexing where non overlapping frequency channels are assigned to different signals. A guard band is left between the signals to prevent the signals from overlapping with the adjacent signal. By leaving this guard band the band width is consumed and it also decreases the systems information rate when compared to a single carrier modulation system. To use the bandwidth efficiently orthogonal frequency division multiplexing is used (OFDM) [2,3 4]. In OFDM a large number of closely spaced sub carriers which are orthogonal to each other are used to carry data. Orthogonality here says that orthogonal sub carriers are used that is the spectrum of the sub carriers are overlapped, it increases the spectral efficiency. The signals are said to be orthogonal to each other when the dot product of two signals is equal to zero. Here the signals are independent with each other. The total data sent into the channel is divided between sub carriers. Each sub-carrier is modulated with a modulation scheme (BPSK, QPSK, and QAM) where the data rates are similar to the single carrier modulation scheme in the same bandwidth [5].

II. OFDM

A block schematic of OFDM modem is shown in Fig 1. In OFDM, the input data is sent to a serial-to-parallel converter (the S/P block). Then, the N parallel outputs of the S/P block is given to the modulator and the modulated is given to the Inverse Fast Fourier Transform (IFFT) block in order to convert the frequency domain signals to time domain signals. After the IFFT has been computed, the N complex numbers at the output of the IFFT block are given to parallel-to-serial converter [6]. Then, the Cyclic Prefix (CP) is inserted in order to combat the Inter Symbol interference

(ISI) caused by the multipath channel. The Cyclic Prefix or Guard Interval is a periodic extension of the last part of an OFDM symbol that is added to the front of the symbol in the transmitter, and is removed at the receiver before demodulation. At the receiver side, removal of the cyclic prefix is performed and then signals are given to serial to parallel converter block where the signals are converted to parallel data and the output of the S/P block is given to FFT block. The FFT block converts the time domain signal to frequency domain signal. The output bit stream is obtained by converting the output of the FFT block into a serial bit stream [7, 8].

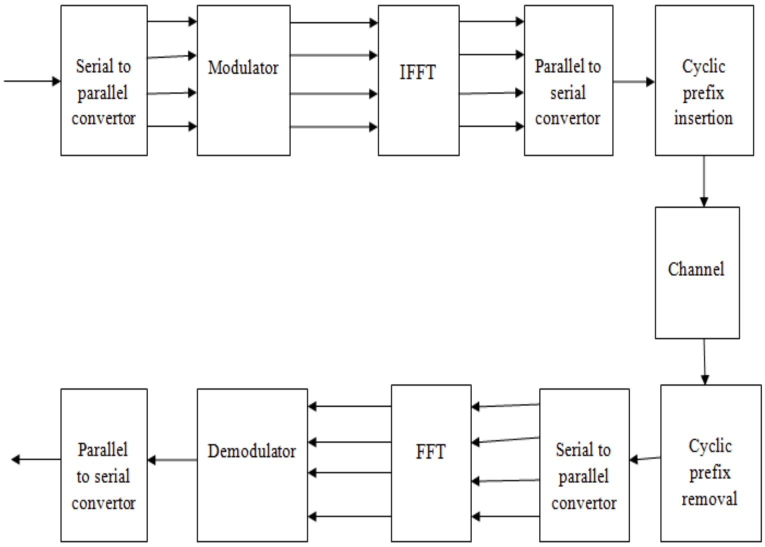

Fig. 1 Block diagram of OFDM system.

III. MIMO

Multiple inputs multiple output (MIMO) is one of the advancements regarding digital communications. To improve bit error rate performance and provide high data rate MIMO is used. There are two techniques in MIMO with respect to how data is transmitted across the given channel. They are spatial diversity and spatial multiplexing.
Spatial Diversity: It is a type of Diversity in which two (or) more number of signals sent over different paths by using multiple antennas at transmitting and receiving sides.

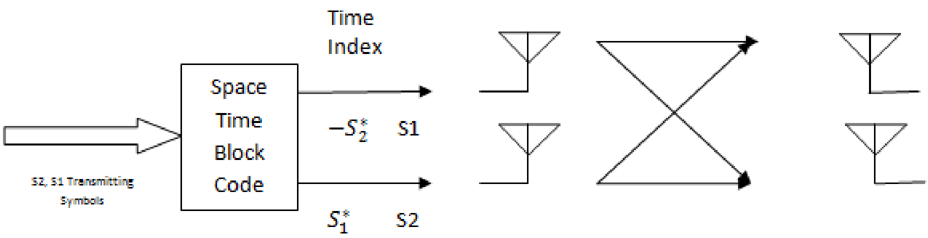

Fig. 2 Block Diagram of Spatial Diversity

Spatial Multiplexing: In MIMO Multiple antennas are used to send and receive the data. Spatial multiplexing has been generally used to increase the capacity of a MIMO link by transmitting independent data streams in the same time slot and frequency band simultaneously from each transmit antenna, and differentiating multiple data streams at the receiver using channel information about each propagation path [9, 10]. MIMO is having multiple antennas at both transmitter and receiver. There are SISO, SIMO MISO technologies before the use of MIMO. SISO means the system having single transmitter and single receiver and SIMO means having single transmitter and multiple

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receivers and in the same way MISO means having multiple transmitters and single receiver. To get better results both OFDM and MIMO techniques are combined therefore MIMO-OFDM system is introduced.

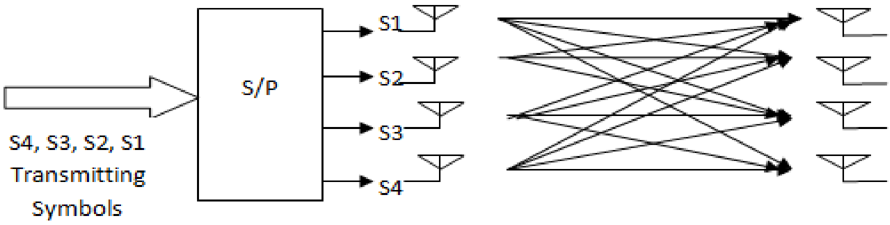

Fig.3. Block Diagram of Spatial Multiplexing

IV. MIMO-OFDM SYSTEM MODEL

MIMO-OFDM block diagram is shown in the figure 4. In that information source generates the random data, the data is given to the modulator and the modulation schemes followed here are BPSK, QPSK, and QAM. The modulated data is given to the space time block coding (STBC) encoder. Space time block coding is a method used in the spatial diversity which increases reliability. As said above here multiple copies of same data is sent across independent fading channels, if each channel is suffered by fading, each channel has different fading effect. So among all channels any one channel may suffer with less fading compared to others. So the chance of receiving the proper transmitted data is more and improves the reliability of the system. The encoded data is given to the Inverse Fast Fourier Transform (IFFT) block, where the time domain signal is converted into frequency domain. At the end of the transmitter peak to average power ratio (PAPR) value is calculated and finally the data is sent to the receiving antennas by using transmitting antennas. At the receiver side first FFT operation is performed this scheme; this processed data is decoded using STBC decoder. Decoder gives the appropriate signal from all receiving signals after that demodulation operation is performed finally original information is received at destination [11, 12, 13].

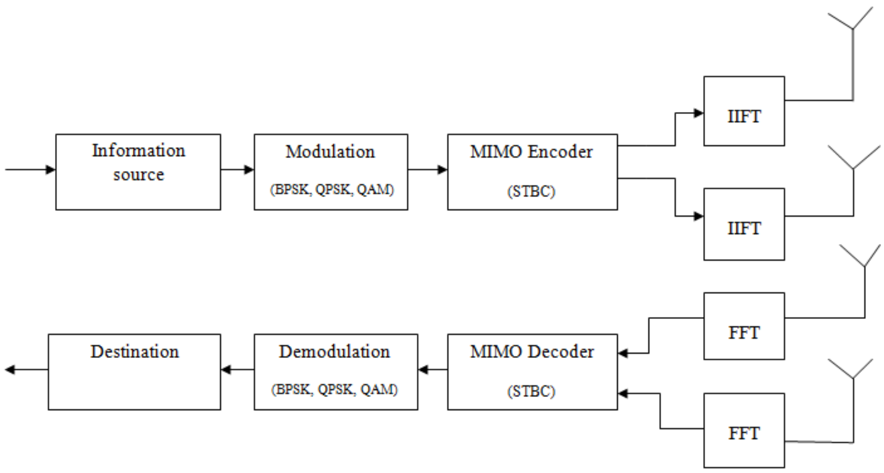

Fig.4 Block diagram of MIMO-OFDM

V. PEAK TO AVERAGE POWER RATIO

High Peak-to-Average Power Ratio has been recognized as one of the major practical problem involving OFDM modulation. High PAPR results from the nature of the modulation itself where multiple subcarriers (or) sinusoids are added together to form the signal to be transmitted. When N sinusoids add, the peak magnitude would have a value of N, where the average might be quite low due to the destructive interference between the sinusoids. High PAPR signals

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are usually undesirable for it usually strains the analog circuitry. High PAPR signals would require a large range of dynamic linearity from the analog circuits which usually results in expensive devices and high power consumption with lower efficiency (for e.g. power amplifier has to operate with larger back-off to maintain linearity). In OFDM system, some input sequences would result in higher PAPR than others. For example, an input sequence that requires all such carriers to transmit their maximum amplitudes would certainly result in a high output PAPR. Thus by limiting the possible input sequences to a smallest sub set, it should be possible to obtain output signals with a guaranteed low output PAPR. The ratio of peak to average power value is termed as PAPR. This is the problem which occurs in MIMO-OFDM system. Because of multiple subcarriers power output increases greatly and become higher than the mean power of the system. To transmit the signals with high PAPR requires power amplifiers with high power. These are very expensive. PAPR reduces the performance increases the complexity in A-D and D-A convertors and reduces the efficiency of RF amplifiers.

$$PAPR = \frac{\max|x(t)|^2}{E\left[|x(t)|^2\right]}$$

Where, $\max|x(t)|^2$ =Peak Signal Power $E\left[|x(t)|^2\right]$ =Average Signal Power.

VI. RESULTS AND DISCUSSION

The evaluation of PAPR is examined by MATLAB simulation. To evaluate the performance, the complementary cumulative distribution (CCDF) is used. The CCDF of PAPR for OFDM signal x is,

$$\text{ccdf}(\text{papr}(x)) = P_T(\text{papr}(x) > \text{papr } 0$$

The CCDF of the PAPR denotes the probability that the PAPR of a data block exceeds a given threshold. The PAPR and BER are calculated under different modulation schemes for a MIMO-OFDM system.

A. PAPR Performance :

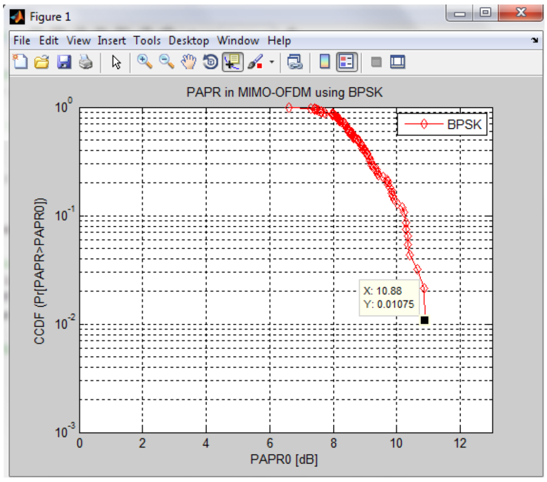

Fig. 5 CCDF plot for a MIMO-OFDM system for BPSK

Figure 5 shows the CCDF plot for a MIMO-OFDM system under BPSK modulation where PAPR value is 10.88 db at CCDF 0.021.

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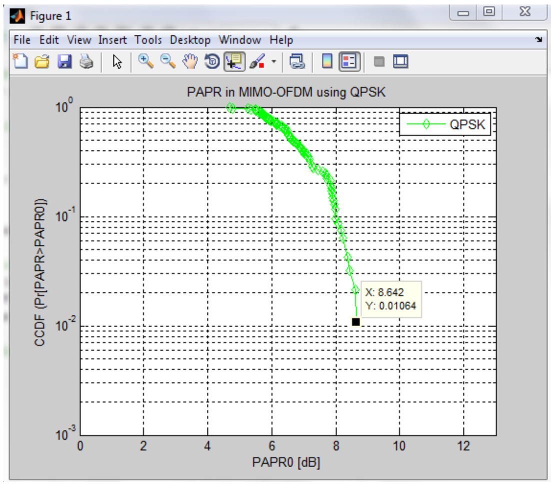

Fig. 6 CCDF plot for a MIMO-OFDM system for QPSK

Figure 6 shows the CCDF plot for a MIMO-OFDM system under QPSK modulation scheme where PAPR value is 8.642 db at CCDF 0.021.

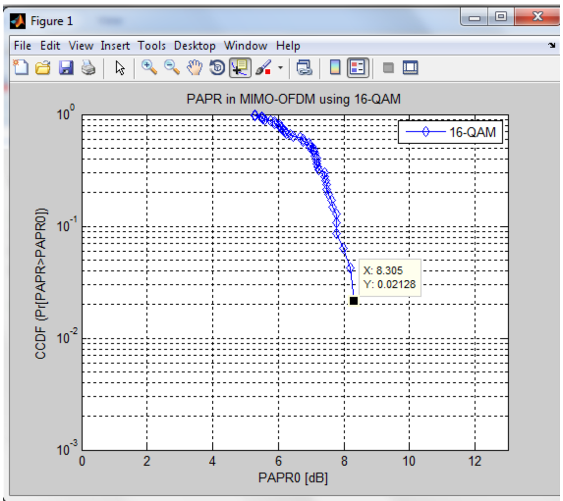

Fig. 7 CCDF plot for a MIMO-OFDM system for QAM

Figure 7 shows the CCDF plot for MIMO-OFDM system under QAM modulation scheme where PAPR value is 8.305db at CCDF 0.021. Compared to BPSK modulation, QAM modulation has degradation in PAPR value from 10.88db to 8.305db. Therefore QAM modulation has less PAPR.

VII. BIT ERROR RATE

In digital transmission, the number of bit errors is the number of received bits of a data stream over a communication channel that has been altered due to bit synchronization errors, noise, interference and distortion. The bit error rate or bit error ratio (BER) is the number of bit errors divided by the total number of transferred bits during a studied time interval. BER is often expressed as a function of the normalized carrier-to-noise ratio measured denoted Eb/N0 that is energy permit to noise power spectral density ratio, or Es/N0 that is energy per modulation symbol to noise spectral density. As the name implies, a bit error rate is defined as the rate at which errors occur in a transmission system.bit error rate can be define as:

BER = number of errors/ total number of bits sent.

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If the signal to noise ratio is high and medium between the transmitter and receiver is good then the bit error rate will be very small-possibly insignificant and having no noticeable effect on the overall system However if noise can be detected, then there is chance that the bit error rate will need to be considered

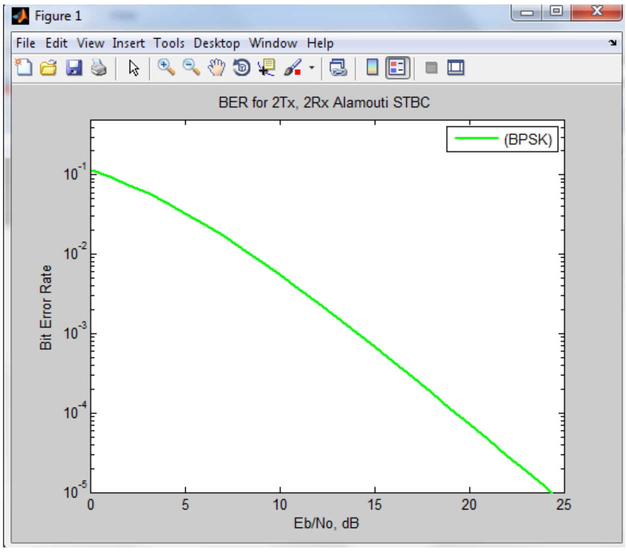

Fig.8 Simulation result for MIMO-OFDM system for BPSK modulation

Figure 8 shows the plot for bit error rate of 2*2 MIMO-OFDM systems for BPSK modulation and bit error rate is 24

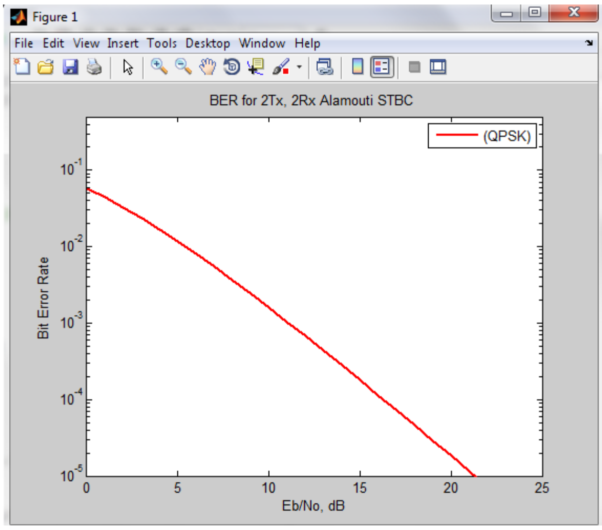

Fig.9 Simulation result for MIMO-OFDM system for QPSK modulation

Figure 9 shows the plot for bit error rate of 2*2 MIMO-OFDM systems for QPSK modulation and the value is 21.

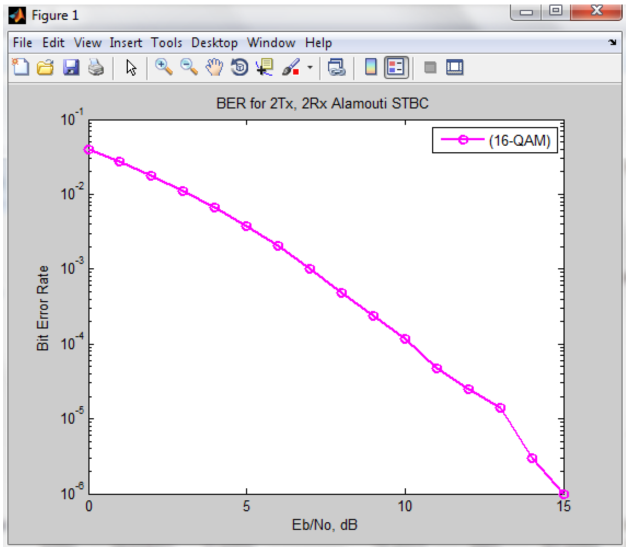

Fig.10 Simulation result for MIMO-OFDM system for QAM modulation

Figure 10 shows the plot for bit error rate of 2*2 MIMO-OFDM systems for QAM modulation and the value is 15. Comparing these modulation techniques, QAM modulation has better results with less bit error rate.

VIII. CONCLUSION

In this paper the performance of MIMO OFDM system by using different modulation schemes (BPSK, QPSK) under various fading channels (RAYLEIGH CHANNEL and AWGN CHANNEL) is analysed. The bit error rate for the OFDM and also for the MIMO-OFDM systems is calculated and compared for the different SNR values. After analysing the results, BPSK and QPSK in OFDM has greater bit error rates when compared to the BPSK and QPSK in MIMO-OFDM. This is because of the STBC coding. In STBC we are sending the same symbol two times in the orthogonal passion. So it can reduce the fading effect and also if at all a receiver is failed to receive the symbol in one time slot it can receive the symbol in another time slot so the information may not be lost.

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