Performance Improvement in MIMO OFDM by PAPR Minimization using Probabilistic Method

Gowshameed, Chanemougapriya

Abstract— **The rapid growth of the Digital Communication in recent years, the need for high speed transmission has increased. New multicarrier modulation technique such as MIMO OFDM is implemented. Therefore MIMO OFDM has one of the major disadvantages is that PAPR problem. MIMO OFDM system is known to have a high PAPR when compared with single carrier system. In fact the high PAPR is one of the most determined aspects in the MIMO OFDM system. The PAPR problem is more important in uplink since the efficiency of Power amplifier is critical due to the limited battery power in a Mobile terminal. One of the most powerful techniques known Probabilistic method, to reduce the PAPR has to be implemented in this project. In this performance of the Probabilistic method with Walsh code generation, effect of phase rotation, BER performance is discussed with simulation results.**

***Index Terms*— BER, MIMO-OFDM, PAPR, Probabilistic method, Walsh code.**

I. INTRODUCTION

Multiple Input Multiple Output (MIMO) in combination with Orthogonal Frequency Division Multiplexing (OFDM) holds the ability to drastically improve spectral efficiency and link reliability in future wireless communications systems. In MIMO-OFDM system, a number of antennas are placed at the transmitting and receiving ends and the distances are placed far enough. The idea is to use spatial multiplexing and data pipes by developing space dimensions which are created by multi transmitting and receiving antennas. The transmitted signal bandwidth is so narrow that its frequency response can be assumed as being flat. However there is one main disadvantage of MIMO-OFDM that is the high peak-to-average power ratio (PAPR) of the transmitter's output signal on different antennas. High Peak to Average Power Ratio (PAPR) for MIMO-OFDM system is still a demanding area and difficult issue.

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II. PEAK-TO-AVERAGE POWER RATIO

A. Introduction

In general, even linear amplifiers impose a nonlinear distortion on their outputs due to their saturation characteristics caused by an input much larger than its nominal value. The input-output characteristics of high power amplifier (HPA) in terms of the input power Pin and the output power Pout. Due to the aforementioned saturation characteristic of the amplifier, the maximum possible output is limited by P^{max}_{out} when the corresponding input power is given by P^{max}_{in}. The input power must be backed off so as to operate in the linear region. Therefore, the nonlinear region can be described by IBO (Input Back-Off) or OBO (Output Back-Off).

$$IBO = 10log_{10}\frac{P_{in}{}^{max}}{P_{in}} \quad (1)$$

$$OBO = 10log_{10}\frac{P_{out}{}^{max}}{P_{out}} \quad (2)$$

B. Definition of PAPR

PAPR is the ratio between the maximum power and the average power of the complex pass band signal. PAPR can be calculated in dB by:

$$PAPR(x) = 10\log_{10}\frac{\max\left\{|x_n|^2\right\}}{E\left\{|x|^2\right\}} \quad (3)$$

C. Principal Algorithm for Reducing PAPR

PAPR is a historic issue in the development of the Wireless communication, the more PAPR of OFDM the more requirements and challenges for implementing the HPA. However the PAPR is calculated from the peak-amplitude of

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the waveform divided by the average value of the waveform as follows:

$$PAPR = \frac{max_{0 \le t \le nT} |x_n|^2}{E\{|x_n|^2\}} \quad (4)$$

The amplitude of x_n has a Rayleigh distribution, while the power has a central chi-square distribution with two degrees of freedom. The distribution of PAPR states in the term of a Complementary Cumulative Distribution Function (CCDF) which can be given as following:

$$CCDF = Pr (PAPR<PAPR0 = A) \quad (5)$$

Assume A = PAPR0.

$$F_x(PAPR0) = P_r\left(\frac{max_{0 \le t \le nT} |x_n|^2}{E\{|x_n|^2\}} < PAPR0\right) = 1 - \exp(-PAPR0) \quad (6)$$

$$CCDF = P_r(PAPR > PAPR0) = 1 - F_x(PAPR0)^N = 1 - (1 - \exp(-PAPR0)^N \quad (7)$$

The decibel form for above Equation is as following:

$$PAPR_{dB} = 10log_{10}(PAPR) \quad (8)$$

III. PROBABILISTIC METHOD

The probabilistic technique [7] is to scramble an input data of the OFDM symbols and transmit one of them with the minimum PAPR so that the probability of incurring high PAPR can be minimized. While it does not suffer from the out-of-band power, the spectral efficiency decreases and the complexity increase as the no. of subcarriers increases.

It cannot guarantee the PAPR below a specified level. This approach includes SLM (Selective Mapping), PTS (Partial Transmit Sequence), TR (Tone Reservation), and TI (Tone Injection) techniques.

a. Selective Mapping Technique:

Selected mapping (SLM) is a promising PAPR reduction technique of OFDM system. The main idea of SLM technique is to generate a number of OFDM symbols as candidates and then select the one with the lowest PAPR for actual transmission from a number of different data blocks (independent phase sequences) that have the same information at the transmitter. [13,16,17] In the SLM method, the vectors from the original frequency domain OFDM signal are rotated based on a set of predefined phase arrays. For each signal variant obtained, its corresponding PAPR is evaluated. The one with the lowest PAPR is chosen for the transmission. [3]

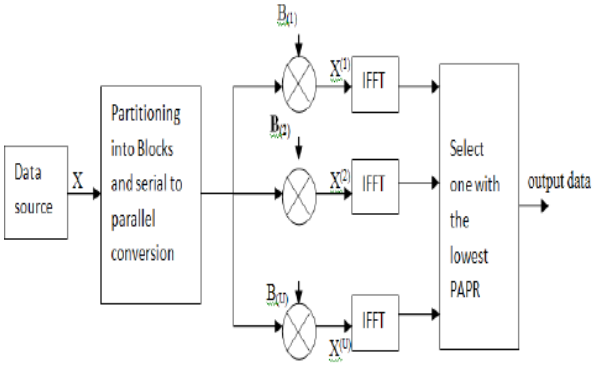

Fig: 1 Block diagram of Selective mapping technique

b. Clipping and filtering method:

A high PAPR brings disadvantages like increased complexity of the ADC and DAC and also reduced efficiency of radio frequency (RF) power amplifier. One of the simple and effective PAPR reduction techniques is clipping, which eliminate the signal components that exceed some unchanging amplitude called clip level. In Clipping, the amplitudes of the input signal are clipped to a threshold value. However, clipping yields distortion power, which called clipping noise, and expands the transmitted signal spectrum, which causes interfering. [10-11]

Clipping and filtering technique is effective in removing components of the expanded spectrum. Although filtering can reduce the spectrum growth, filtering after clipping can eliminate the out-of-band radiation, but may also cause some peak re-growth, which the peak signal exceeds in the clip level. [12]

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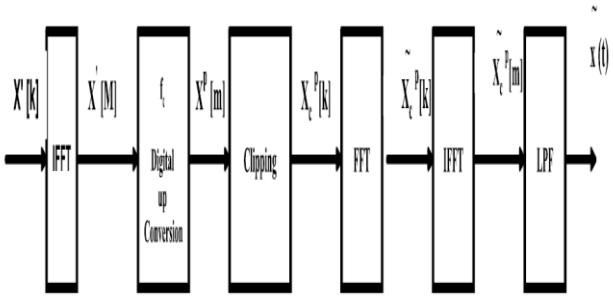

Fig: 2 Block diagram of Clipping and filtering

IV. COMPLEMENTARY CUMULATIVE DISTRIBUTIVE FUNCTION (CCDF)

The probability of PAPR exceeding a threshold as measurement index to represent the distribution of PAPR. This can be described as "Complementary Cumulative Distribution Function" (CCDF) and its mathematical expression

$$CCDF\left(PAPR(x(N))\right) = P_r\left(PAPR(x(N))\right) > PAPR_0 \quad (9)$$

Due to the independence of the N samples, the CCDF of the PAPR of a data block with Nyquist rate sampling is given by

$$P = P_r\left(PAPR(x(N))\right) > PAPR_0 = 1 - (e^{-PAPR_0})^N \quad (10)$$

V. RESULTS AND DISCUSSION

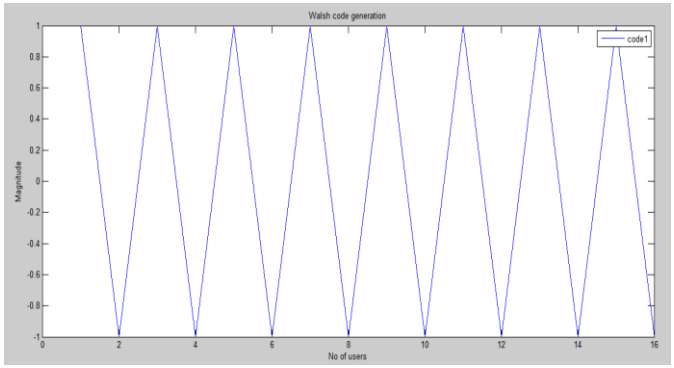

Fig: 3 Generation of Walsh code

Figure 3 shows the generation of Walsh code for 128 users. It is one of the efficient spreading techniques. It shows No. of users Vs magnitude of the sequence.

The below fig. 4 show that PAPR performance of the MIMO OFDM of clipping and filtering. The fig which compares the original signal with different clip and filter values. It shows 11.5dB for Original signal, after the 4th clip and filters the PAPR values reduced to 6.5dB. In this method PAPR values efficiently reduced to 5dB.

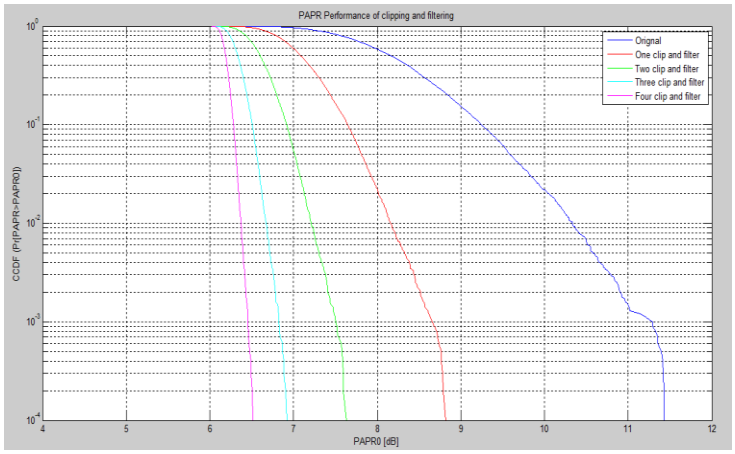

Fig: 4 Performance of the PAPR using clipping and filtering

Performance Comparison of clipping and filtering				
	Original	One Clip & Filter	Two Clip & Filter	Three Clip & Filter
PAPR	11.5dB	8.8dB	7.6dB	6.9dB

Table: 1 Performance Comparison of clipping and filtering

The below fig. 5 show that proposed method of Selective Mapping Technique which compares the original signal with SLM signal. In this method the Original signal's PAPR is reduced by11.5dB is reduced by 7.5dB.

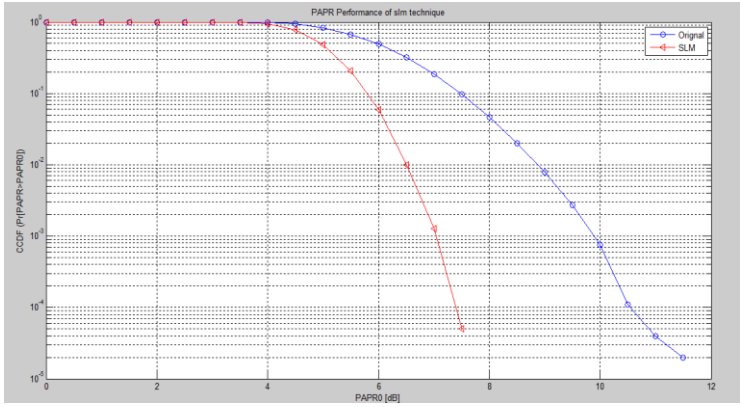

Fig: 5 Performance of the PAPR using Selective Mapping Technique

Performance Comparison of SLM Technique				
	Existing		Proposed	
	Original	Using SLM	Original	Using SLM
PAPR	12dB	8dB	11.5dB	7.5dB

Table: 2 Performance Comparison of SLM Technique

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	Original	N=2	N=4	N=8
PAPR	11.2dB	9.2dB	8dB	6.9dB

Table : 3:Performance Comparison of SLM Technique with different values of N

	M=16	M=8	M=4	M=2	Original
Existing	8.6dB	8.9 dB	9.5 dB	10.2 dB	11.4 dB
Proposed	6.4 dB	6.8 dB	7.6 dB	9.4 dB	10.4 dB

Table 4: Performance Comparison of SLM Technique with different values of M

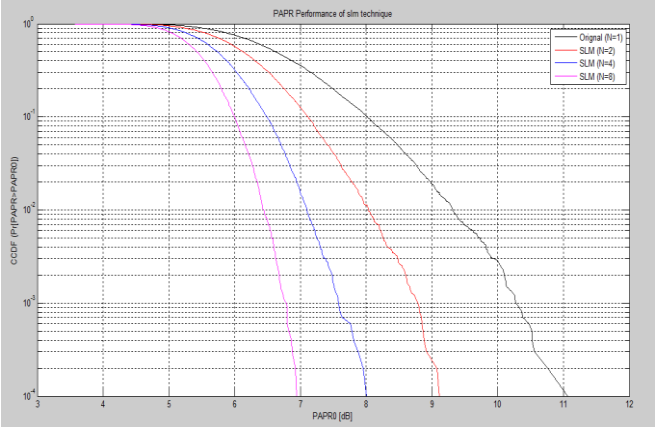

Fig: 6 Performance of Phase rotated Frequency Domain signal in SLM technique.

The above fig. 6 shows that Performance of Phase rotated Frequency Domain signal in SLM technique. At the first phase rotation, the original, the PAPR is 11.2dB at the 8th phase rotation the PAPR is 6.9dB. The PAPR is reduced by 4.2dB.

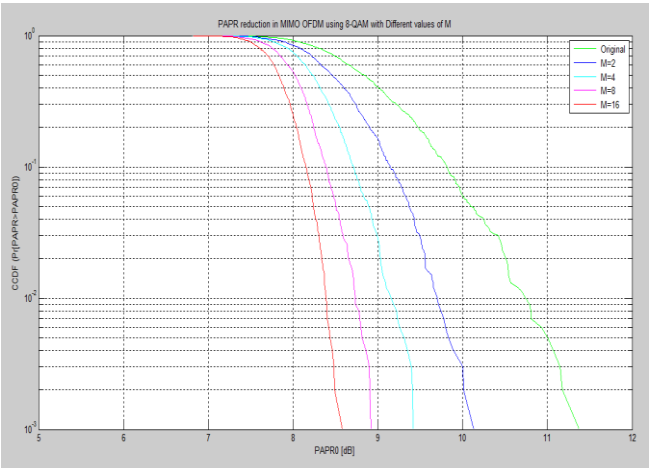

Fig: 7 Existing Performance of the PAPR using SLM with different values of M

The above fig. 7 shows that Performance of selective mapping that affected by route numbers. The original signal having the PAPR value of 11.4dB. The Value of M=16 having the Power of8.6dB.

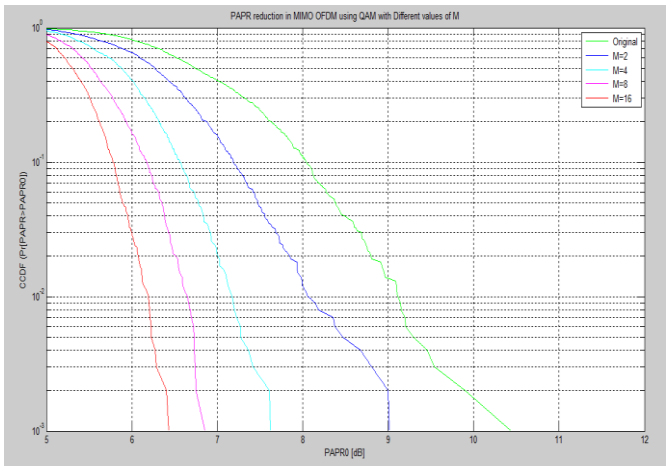

Fig: 8 Proposed Performance of the PAPR using SLM with different values of M

The above fig. 8 shows that Performance of selective mapping that affected by route numbers. The original signal having the PAPR value of 10.4dB. The Value of M=16 having the Power of 6.6dB. The PAPR value is efficiently reduced.

The below fig. 9 shows that performance of the PAPR using SLM technique with Walsh code. The original signal is compared with modified signal having reduced Power of 3dB.

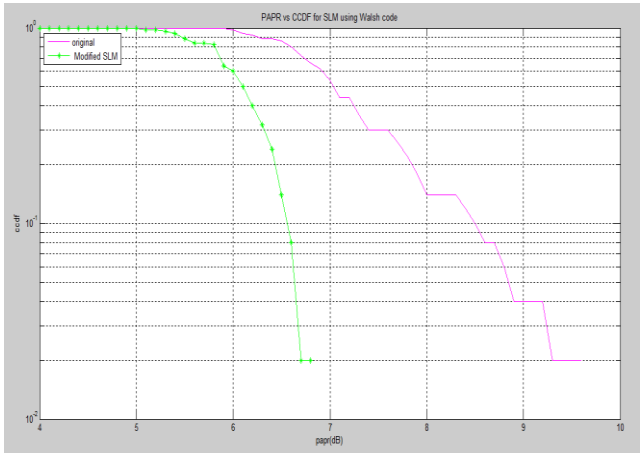

Fig: 9 Performance of PAPR using SLM technique using Walsh code

The below fig.10 shows that effect of Phase rotation in PAPR Reduction. The most of the data similar to each other in MIMO OFDM, it causes the Inter symbol interference in the system. The Phase rotation can reduce the effect of the Interference in the system. In this Phase rotation each data sequence can assign a Different Phase shift.

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	Original	Modified SLM
PAPR	9.5dB	6.7dB

Table 5: Performance Comparison of SLM Technique Using Walsh code

	QPSK	16QAM	BPSK
SNR	36dB	33dB	26dB

Table 6: Performance Comparison of SLM Technique in terms of BER

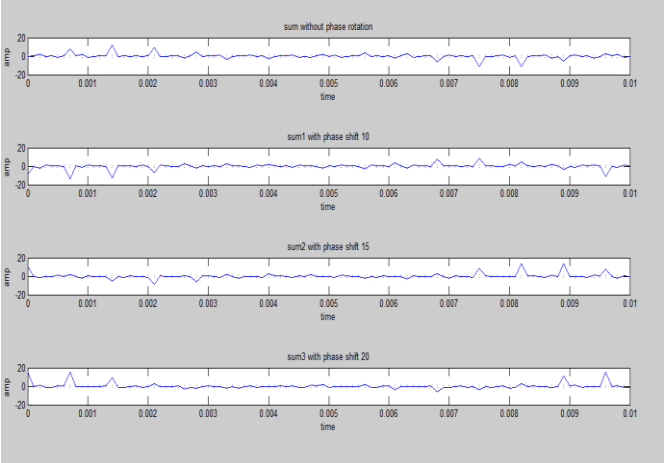

Fig: 10 Effect of Phase rotation

The below fig. 11 shows that Bit Error Performance of the Probabilistic method of which different Modulation technique. In this Bit error performance BPSK, 16QAM QPSK, attains SNR of 26dB, 33dB, 36dB respectively at bit error rate of 10^{-10}.

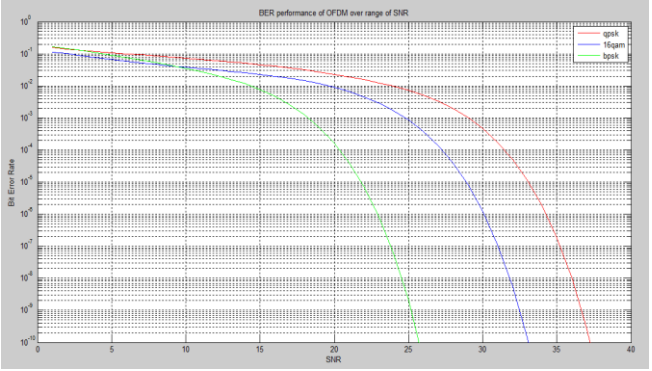

Fig: 11 BER performance of the Probabilistic method

VI. CONCLUSION

This Paper analyzes one of the major drawbacks of the MIMO OFDM. High Peak to Average Power ratio (PAPR) and discuss how to reduce it by different effective system. The main concentration of this paper is to use Powerful technique, Selective Mapping and clipping, which are aimed to reduce high peak power in the system using MATLAB simulation. These two methods are very effective to reduce the PAPR in the MIMO OFDM system. These two approaches provide the better results in reducing High power & achieve the great BER performance. The Walsh code also gives better results. The major advantages is that to reducing the hardware complexity. In the first part of the simulation, clipping provide better performance of 5dB reduction when compared to others. In the second part of the simulation, SLM achieve the moderate power of 4dB along with better BER performance.

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