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Research Article

PAPR Reduction in MIMO-OFDM System using Clipping Technique

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Abstract

Orthogonal Frequency-Division Multiplexing (OFDM) is a multicarrier transmission scheme. It has various advantages like easy and efficient in dealing with multi-path, robust against narrow-band interference, supports various modulation schemes and perfect for Multiple Input Multiple Output (MIMO) technique. OFDM is combined with MIMO, called MIMO-OFDM. This improves the bandwidth efficiency of the system and increase the capacity of the system. This technique is used in fourth generation (4G) mobile radio communication. OFDM has one major drawback of high Peak to Average Power Ratio (PAPR). This high PAPR is reduced by the clipping method. In which a threshold value of the amplitude is set. If amplitude of the multicarrier modulated signal is more than the threshold value then the signal is clipped. A big advantage of clipping is that PAPR reduction is obtained without any redundancy and no side information is needed to transmit but there is some distortion in data received at receiving end. Simulation result shows that clipping technique improves the PAPR and degrades the Bit Error Rate (BER) performance. In addition, for various clipping levels PAPR and bit error rate is investigated.

Keywords: *OFDM, MIMO, MIMO-OFDM, PAPR, BER.*

1. Introduction

In Wireless communication systems data transfer rate of even one Giga bits per Second is not enough for multimedia applications such as high quality audio and video. The demand of high data rate will increase in future as the quality of multimedia application increases. Most of the wireless techniques cannot provide efficiently data rates, because these techniques are very sensitive to fading. Therefore a technique is needed to improve not only the data transfer rate but high transmission reliability also. Solution to this problem is Orthogonal Frequency Division Multiplexing (OFDM). OFDM is a multicarrier transmission scheme. In OFDM digital data are encoded on multiple carrier frequencies [R. V. Nee *et al*., T. Hwang *et al*.]. In a multipath wireless channel environment, high data rate of transmission can be achieved by Multiple Input Multiple Output (MIMO) systems without increasing the total transmission power or bandwidth. An effective and practical way to approaching the capacity of MIMO wireless channel is to employ space-time block coding in which data is coded through space and time to improve the reliability of the transmission, in STBC redundant copies of the original data are sent over independent fading channels [T. Jiang *et al*., Y. Rahmatallah *et al*.]. Then all the signal copies are combined at the receiver in an optimal way to extract as much information from each of them as possible. In STBC where at a given symbol period, two signals are transmitted simultaneously from the two antennas. To address these challenges, a promising combination has been exploited, namely, MIMO-OFDM. This increases the diversity gain and enhances the system capacity [S. Catreux *et al*.]. This has been adopted for present and future broadband communication standards such as LTE or WiMAX. In wireless communication MIMO-OFDM is very potential candidate for cellular communications (3GPP-LTE, Mobile WiMAX, IMT-Advanced) as well as wireless LAN (IEEE 802.11a, IEEE 802.11n) [S. Shrikanth *et al*.]

Apart from various advantages, MIMO-OFDM suffers from serious drawback of its high peak to-average power ratio (PAPR). PAPR is the ratio maximum power of the sample in a given OFDM transmit symbol to the average power of that OFDM symbol. PAPR occurs when in a multicarrier system the different sub-carriers are out of phase with each other and produces a problem of undesired in-band distortion and out-of-band radiation for High Power Amplifier (HPA) [S. H. Han *et al*.]. PAPR limits the transmission power due to the limitation of dynamic range of Analog to Digital Converter and Digital to Analog Converter (ADC/DAC) and power amplifiers at the transmitter, which in turn sets the limit over maximum achievable rate. This issue is especially important for mobile terminals to sustain longer battery life time. High PAPR creates problem while selecting the power amplifier, as large dynamic range of power amplifier is

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needed to amplify the high peaks of the signal and thus the cost of transmitter is increased because amplifier of such a dynamic range is very costly and bulky too. PAPR also reduces the power efficiency which results in low battery life time. It is therefore very much important to reduce the PAPR [T. Jiang *et al*]. In this paper clipping based MIMO-OFDM is analyzed. This study investigates that clipping technique improves the PAPR and degrades the bit error rate performance. In addition, for various clipping levels PAPR and bit error rate is investigated.

The rest of the paper is organized as follows: Section 2 describes of the transmitter model for MIMO-OFDM with clipping technique. Simulation results are shown in section 3 and paper is concluded in section 4.

2. System Model

MIMO-OFDM with clipping technique is considered for the system model which is described in next section.

2.1 MIMO-OFDM with Clipping Technique

MIMO-OFDM transmitter with clipping technique is shown in Fig-1. Randomly generated data are encoded by channel encoding. This coded data are modulated. The multicarrier modulated signal is obtained after IFFT processing.

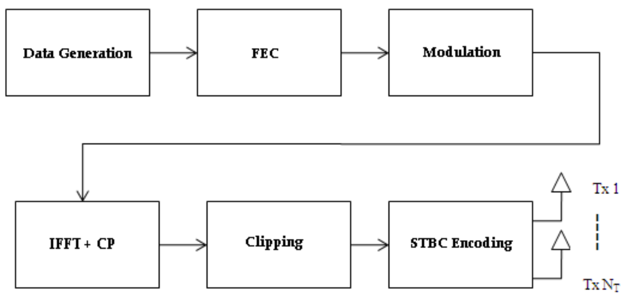

Fig.1 MIMO-OFDM with clipping technique

The continuous time OFDM modulated signal is given by [T. Hwang, *et al.*]

$$x(t) = \sum_{i=1}^{M} x_k \, e^{2\pi k \Delta f t} \qquad 0 \le t \le T_s \tag{1}$$

Where T_s, Δf and M are the symbol duration, the subcarrier space, and number of subcarriers of the OFDM signals, respectively. These multicarrier modulated signals are clipped by clipping technique. This reduces the PAPR of multicarrier modulated time domain signal. PAPR is the ratio of maximum powers to the average power of continuous time OFDM signal. The OFDM signal has many independently modulated subcarriers, which may lead to large PAPR for some OFDM symbols. When M signals have the same phase, they produce a peak power, which is M times the average power.

The PAPR of the continuous time OFDM signal is defined as [S. H. Han *et al.*]

$$PAPR = \frac{Max|x(t)|^2}{E\{|x(t)|^2\}} \tag{2}$$

Where numerator denotes peak power and denominator denotes average power of the OFDM signal respectively. The above power characteristics also defined in terms of their magnitude by defining the Crest Factor (CF)

$$\mathrm{CF} = \sqrt{\mathrm{PAPR}} \tag{3}$$

With the assumption $E\{|x(t)|^2\} = 1$, $PAPR = N$, that is maximum power equivalent to N times the average power. It is expressed in dB as

$$PAPR_{max} = 10log_{10}(N)dB \tag{4}$$

Amplitude clipping is defined as [T. Jiang *et al.*]

$$C(\mathrm{x}) = \begin{cases} x(t), & |x(t)| \le A \\ A, & |x(t)| > A \end{cases}$$

Where A is preset clipping ratio and it is positive real number. This clipped signal is encoded by STBC encoding technique. Finally, these signals are transmitted through multiple transmitting antennas. This technique is also known as distortion technique

3. Simulation Results

Physical layer of fixed WiMAX is simulated using MIMO-OFDM with clipping technique. Each block of transmitter with MIMO-OFDM using clipping technique is individually coded in MATLAB. The simulation parameters are given in Table 1. For FEC, RS and convolution channel coding is used. In channel coding, overall coding rate is taken as ½, and ¾. FOR MIMO STBC encoding is used.

Table 1 MIMO-OFDM using clipping scheme parameters of fixed WiMAX

S.No	Parameters	Values
1	FFT size	256
2	Number of used data subcarrier	192
3	Number of pilot subcarrier	8
4	Number of null/guardband subcarrier	56
5	Cyclic prefix	1/4
6	Coding rate	½, ¾
7.	Clipping Ratio	1,2

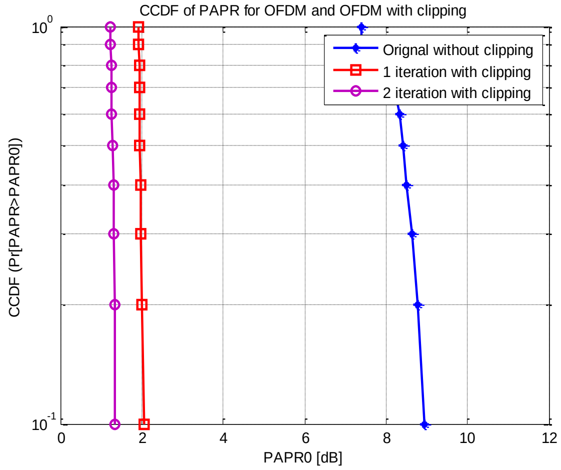

Fig.3 CCDF of PAPR for BPSK, r =1/2 and CR =1

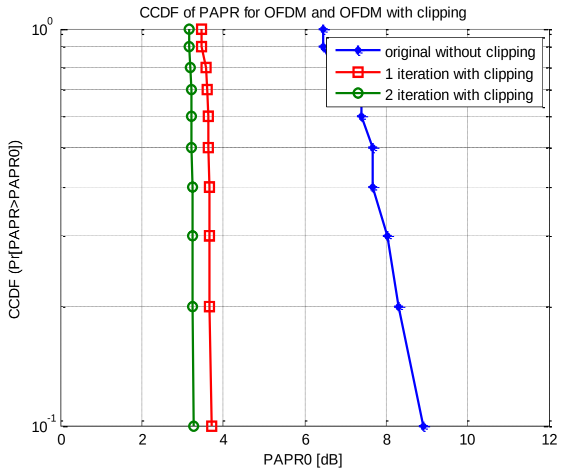

Fig.4 CCDF of PAPR for BPSK, r =1/2 and CR =2

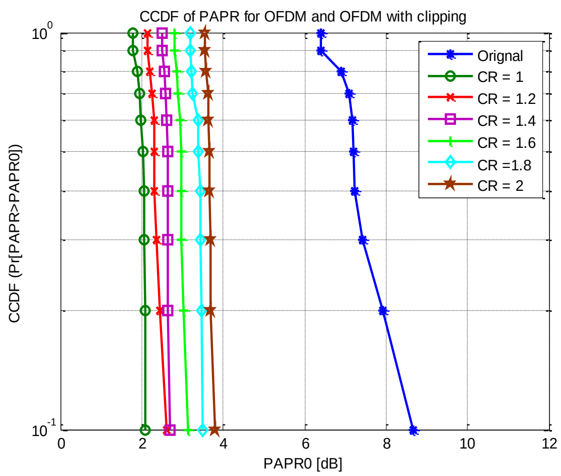

Fig.5 CCDF of PAPR at different clipping ratio, BPSK and r =1/2

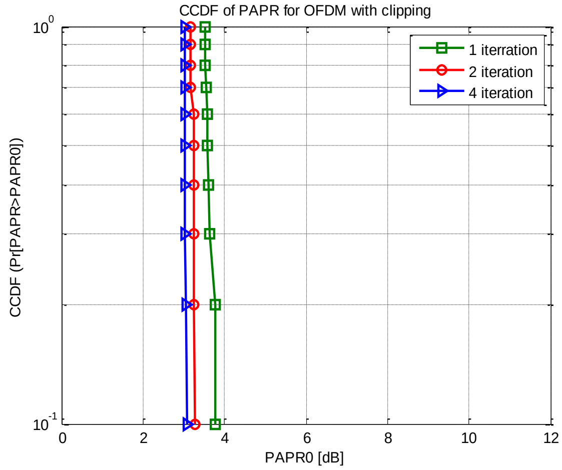

Fig.6 CCDF of PAPR at CR =2, BPSK and r =1/2

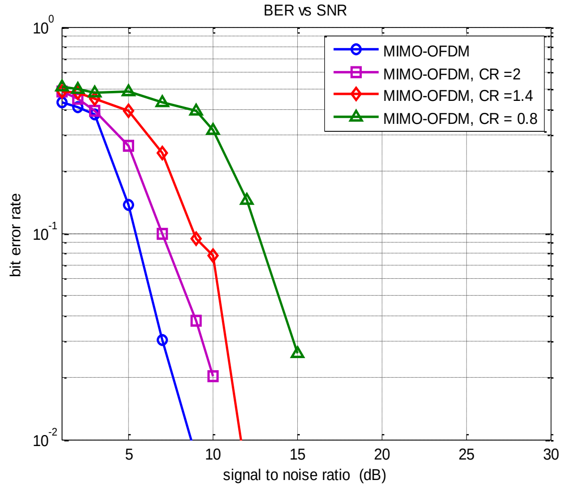

Fig.7 BER versus SNR for BPSK, r = 1/2, $N_T = 2$ and $N_R = 4$

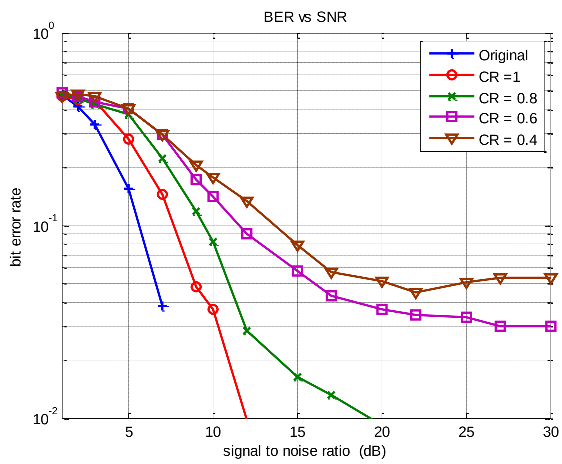

Fig.8 BER versus SNR for QPSK, r = 1/2, $N_T = 2$ and $N_R = 4$

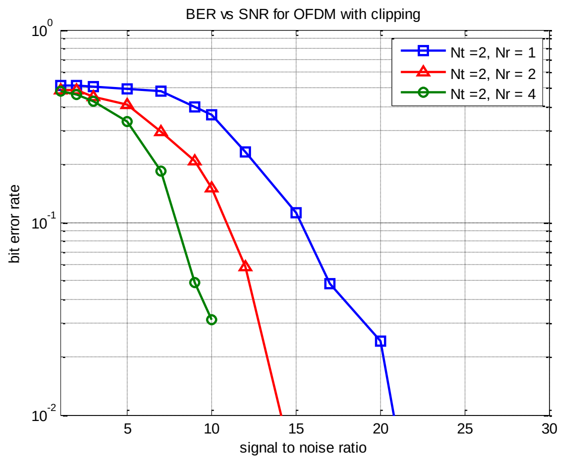

Fig.9 BER versus SNR for BPSK, r = 1/2, CR = 2

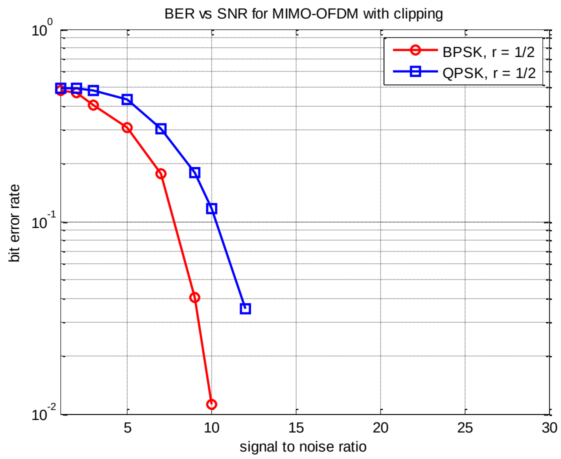

Fig.10 BER versus SNR at CR = 2, $N_T = 2$ and $N_R = 4$

In Fig-3 and 4 comparisons is shown among the OFDM and OFDM with clipping at CR =1 and CR = 2 respectively for BPSK modulation. From results it is observed that PAPR is substantially reduced by applying clipping technique.

Comparison of OFDM and OFDM with clipping system is shown in Fig-5 for BPSK modulation at different clipping ratio. PAPR is reduced by decreasing the clipping ratio.

PAPR is also reduced by increasing the number of iterations. It is shown in Fig-6.

MIMO-OFDM with clipping system results are shown in Fig-7 and 8 at $N_T = 2$ and $N_R = 4$. At different clipping ratio BER vs. SNR comparison is made for BPSK and QPSK modulation techniques. BER gets poor by decreasing the clipping ratio.

In Fig-9 BER vs. SNR comparison at different transmitting and receiving antenna configuration shows that by increasing the receving antenna BER is improved. Finally in Fig - 6 for antenna configuration N_T =2 and N_R = 4, BPSK and QPSK comparison is shown. By the result it is clear that with BPSK modulation BER is less as compared to QPSK.

Conclusions

In this paper MIMO-OFDM with clipping technique is investigated. Simulation results show that improved PAPR is achieved by decreasing the clipping ratio, by increasing the number of iteration. Also from results it is observed that improved bit error rate is obtained with MIMO-OFDM system than the MIMO-OFDM using clipping scheme. By applying clipping scheme BER gets degrade. In addition bit error rate performance is also investigated for BPSK and QPSK modulation techniques. Between these two modulation techniques for BPSK modulation bit error rate is low. For higher order modulation and higher coding rate bit error rate is also higher. Bit error rate gets degrade by increasing the clipping ratio for MIMO-OFDM system using clipping technique..

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