Modified Iterative Clipping and Filtering Technique for PAPR Reduction of Coded OFDM Signal

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Abstract

Orthogonal frequency division multiplexing (OFDM) is a special form of multicarrier modulation scheme, which divides the entire frequency selective fading channel into many orthogonal narrowband flat fading sub channels and a high-bit-rate data stream is transmitted in parallel over a number of lower data rate subcarriers. So in OFDM signal may exhibit a high instantaneous signal peak with respect to the average signal level which can give a large peak-to-average power (PAP) ratio. The clipping is one of the simplest distortion based technique to reduce the PAPR by clipping the signal to the desired level and to limit out-of-band radiation iterative clipping and filtering scheme is used. In this paper, we analyzed PAPR reduction technique, based on repeated clipping and filtering, and its SNR performance. It is shown that we can achieve both PAPR reduction from the ICF technique as well as error performance improvement from the channel coding(Convolution Coding) with no loss in data rate from the transmission of side information.

Keywords— OFDM, PAPR, Convolution coding

1. Introduction

Orthogonal frequency division multiplexing (OFDM) technology is one of the most attractive candidates for fourth generation (4G) wireless communication. It effectively combats the multipath fading channel and improves the bandwidth efficiency. At the same time, it also increases system capacity so as to provide a reliable transmission [1]. OFDM uses the principles of Frequency Division Multiplexing (FDM) [1] but in much more controlled manner, allowing an improved spectral efficiency [1].OFDM is a special case of multicarrier transmission, where a single data stream is transmitted over a number of lower rate subcarriers. The main reason to use OFDM is to increase the robustness against the selective fading or narrowband interference. In single carrier system if signal get fade or interfered then entire link gets failed where as in multicarrier system only a small percentage

of the subcarriers will be affected. However, OFDM faces the Peak-to-Average Power Ratio (PAPR) problem that is a major drawback of multicarrier transmission system which leads to power inefficiency in RF section of the transmitter. A simple PAPR reduction method can be achieved by clipping the time-domain OFDM signal. In this work, we survey the PAPR reduction techniques for OFDM.

In multipath environment the performance of orthogonal frequency division multiplexing degrades which can be improved by introducing some kind of channel coding. The effect of fading on BER of OFDM system can be compensated by using channel coding which results in to a coded-OFDM system.Coded OFDM (COFDM) is the new candidate for application such as Digital audio Broadcast (DAB) and Digital Video Broadcast (DVB-T) due to its better performance in fading environments.

2. Mathematical Analysis of PAPR using CCDF

We suppose an OFDM transmission scheme, where a block of N complex symbols $X=\{X_k, k=0,1,\ldots,N-1\}$ is first sampled with each symbol modulating one of a set of subcarriers $f_k,\{k=0,1,\ldots,N-1\}$. The N subcarriers are chosen to be orthogonal, that $f_k=k\Delta f$,where $\Delta f=1/(NT)$ and T is the original symbol period.It is then transformed into time domain using the inverse fast Fourier transform (IFFT).Therefore, the complex envelope of the transmitted OFDM signals can be written as:

$$x(t) = \frac{1}{\sqrt{N}} \sum_{k=0}^{N-1} X_k e^{j2\pi f_k t} \quad ,0 \leq t \leq NT \quad (1)$$

Cyclic prefix (CP) is a copy of last part of OFDM symbol which is placed in front of the symbol. Multipath transmission causes delay spread,.At receiver, signals from direct path and multipath are received in superposition method. Thus, the received signal suffers degradation termed as fading.With CP, the FFT will not process the next symbol from multipath signal that causes intersymbol interference (ISI). In addition, the orthogonality among subcarriers is not changed and prevents intercarrier intersymbol (ICI).

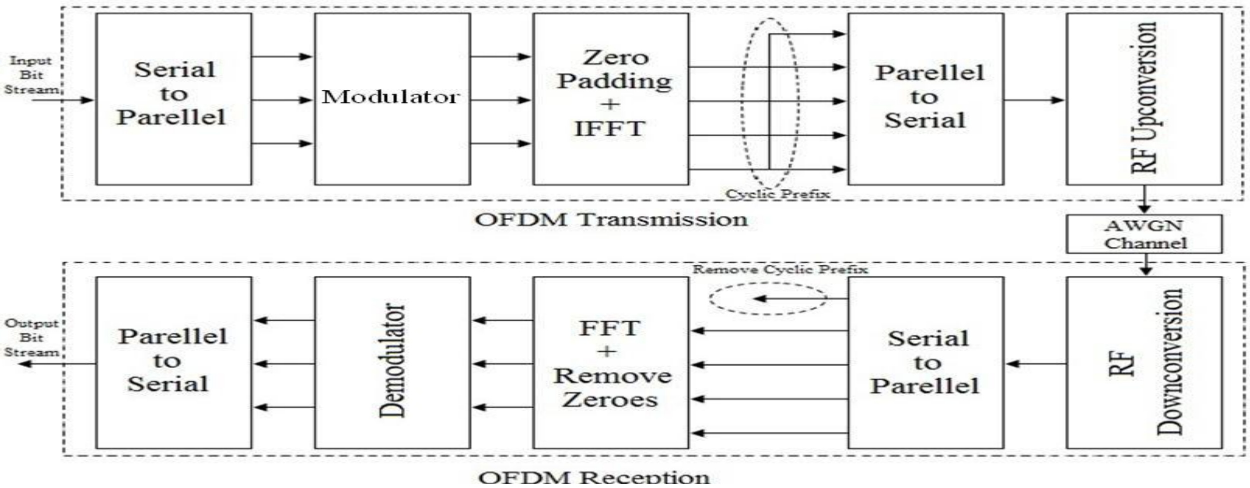

Fig.1.OFDM Transciever block

The PAPR is defined as the ratio between the maximum power occurring in OFDM symbol to the average power of the same OFDM symbol

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

where E{.}denotes the expectation operator

A CCDF curve shows how much time the signal spends at or above a given power level. The power level is expressed in dB relative to the average power. A CCDF curve is basically a plot of relative power levels versus probability.Mathematically CCDF can be explained with a set of data having the probability density function (PDF). To obtain the Cumulative Distribution Function (CDF), the integral of the PDF is computed.Then inverting the CDF results in the CCDF. It concludes that the CCDF is the complement of the CDF or CCDF = 1 –CDF.Cumulative distribution function:Assuming the samples are mutually uncorrelated – which is true for non-oversampling – the probability that the PAPR is below some threshold level can be written as

$$CDF=P(PAPR\leq z)=F(z)^N=(1-e^{-z})^N \quad (3)$$

3. Implementing Coded OFDM

The COFDM system with convolution codes are used for channel coding. The symbol mapping schemes used is 8-QAM .The IFFT/FFT length used is 64. The zero padding is done for confirming the IFFT/FFT size and cyclic prefix is 25% of the IFFT/FFT size, thus making the total size of OFDM frame to 80 symbols. The cyclic prefix compensates the problem caused due to delay spread and maintains continuity of the signal which ensures orthogonal reception of received signal subcarriers.

The purpose of FEC is to improve the capacity of a channel by adding some carefully designed redundant information to the data being transmitted through the channel. Coding allows us to reduce the information bit error rate while maintaining a fixed transmission rate. In principle it allows us to reach Shanon's limit with ingenious coding and enough unlimited complexity. Convolutional encoding with Viterbi decoding is a FEC technique that is particularly suited to a system with AWGN channel**.** Convolutional codes are referred to as continuous codes as they operate on a certain number of bits continuously**.**

Convolutional encoding with Viterbi decoding is a powerful method for error checking. It has been widely deployed in many wireless communication systems to improve the limited capacity of the communication channels.

Convolutional codes are commonly specified by three parameters; (n,k,m).

n= number of output bits

k= number of input bits

m= number of memory registers

The quantity k/n called the code rate, is a measure of the efficiency of the code. Commonly k and n parameters range from 1 to 8, m from 2 to 10 and the code rate from 1/8 to 7/8 except for deep space applications where code rates as low as 1/100 or even longer have been employed.

The quantity L is called the constraint length of the code and is defined by Constraint Length, L = k (m-1).The constraint length L represents the number of bits in the encoder memory that affect the generation of the n output bits.

A viterbi decoder uses the Viterbi algorithm for decoding a bitstream that has been encoded using Forward error correction based on a Convolutional code.The Viterbi algorithm is commonly used in a wide range of communications and data storage applications. It is the most resource consuming, but it does the maximum likelihood decoding.

4. Clipping and Filtering

All Clipping and Filtering (CAF) is practical and effective to cope with the nonlinear distortion problem.CAF clips the time domain transmit OFDM signals by clipping and eliminates the out-of-band radiation by filtering at the same time [1]. OFDM signal after passing through the filter causes the waveform distortion due to eliminating the out-of-band radiation. BER performance of the traditional clipping and filtering method is degraded in comparison with the case without clipping and filtering.

Clipping and Filtering Algorithm:

- The inverse FFT of the input block a is computed. A maximum peak amplitude A is chosen so that the OFDM signal does not exceed the limits of this region, symbols that exceed this maximum amplitude, will be clipped.At the IFFT output, the peaks exceeding a threshold A are clipped. For amplitude clipping, that is

$$C(x) = \begin{cases} x, & x \leq A \\ A, & x > A \end{cases} \quad (3)$$

where A is preset clipping level and it is a positive real number.

- Clipping may introduce in band as well as out of band distortion which may cause BER degradation .This can be avoided by using filtering. The clipped signal is converted into frequency domain by forward Fourier transform; only first N/2 and last N/2 components are taken and all other samples are set to zero; inverse Fourier transform of vector gives the filtered time-domain signal. Filtering makes peaks to re-grow beyond the original clipping threshold, thus increasing the signal PAPR.

- In the iterative clipping and filtering (ICF) scheme the regrown pulses are clipped and filtered in an iterative fashion until target PAPR is obtained.

- We are using Coded-OFDM system here the BER is much better then corresponding uncoded OFDM system with clipping and filtering.

5. Simulation parameters and Result

All the simulations are done in MATLAB 7.0 and simulation parameter are chosen as follows:

Convolution Coding:A polynomial description of a convolutional encoder describes the connections among shift registers and modulo-2 adders and the constraint lengths of the encoder form a vector whose length is the number of inputs in the encoder diagram. The elements of this vector indicate the number of bits stored in each shift register, including the current input bits.To use the polynomial description with the functions convenc and vitdec, first convert it into a trellis description using the poly2trellis function.

trs = poly2trellis(3,[6 7]);

Channel Coding	Convolution coding
Constraint length	3,generator matrices=[110],[111]
Mapping	8-QAM
FFT size	20
Number of subcarriers	52
Channel	AWGN
Decoding	Viterbi decoding

Performance analysis in terms of PAPR and SER for various cases is as follows. Fig. 2 and Fig. 3 shows PAPR comparison for Coded and uncoded OFDM .

PAPR for Uncoded OFDM=6.9447
PAPR of Coded OFDM=6.6767

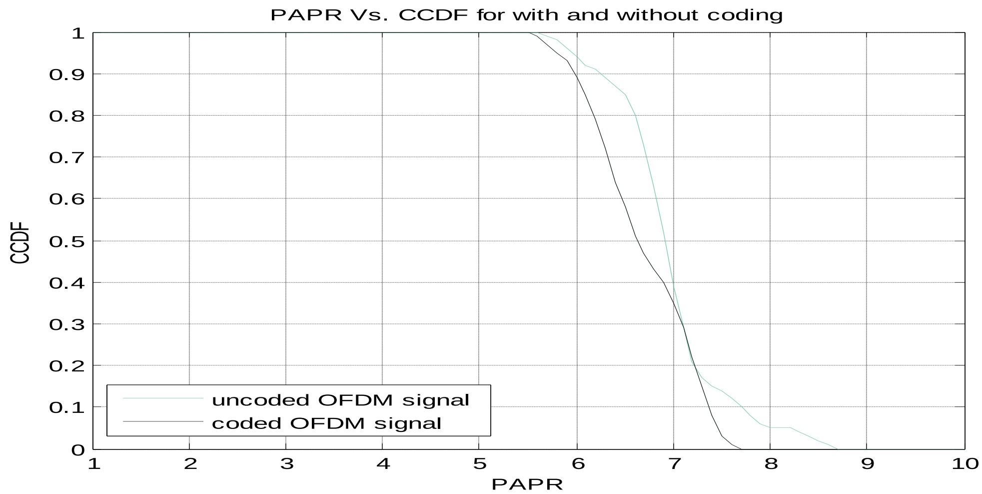

Fig.2.PAPR comparison of coded and Uncoded OFDM signal

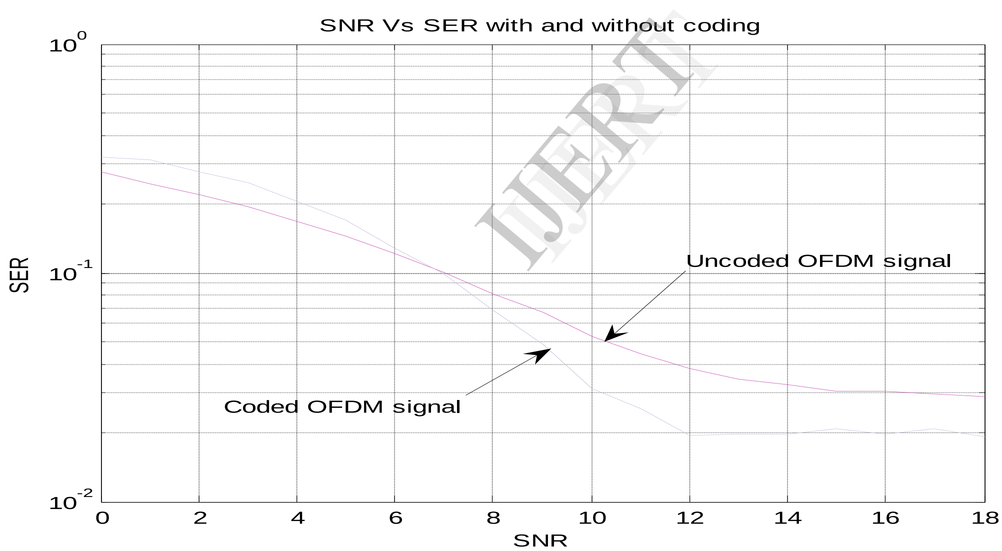

Fig.3.SER comparison of Coded and uncoded OFDM signal

Fig 4 and Fig.5 compares PAPR and SER performance of coded OFDM system in AWGN channel With and without Filtering the clipped signal.

PAPR without filter=6.8199
PAPR with Filter(Hamming Window)=6.6631

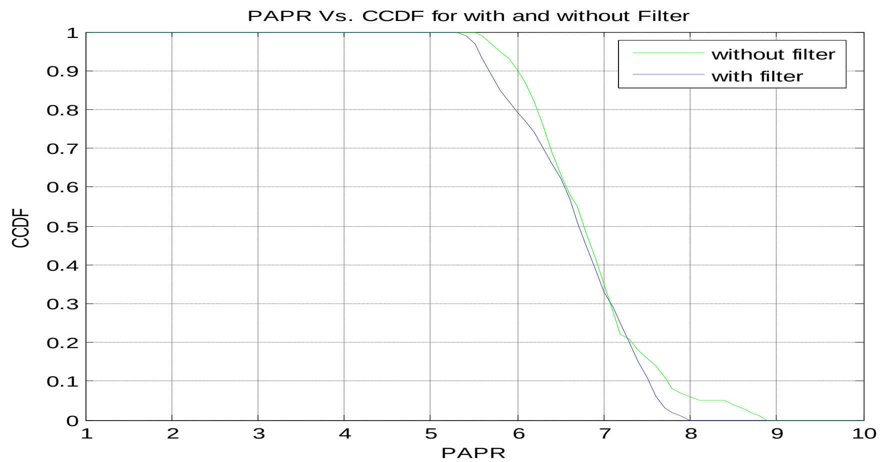

Fig.4.PAPR comparison with and without filter

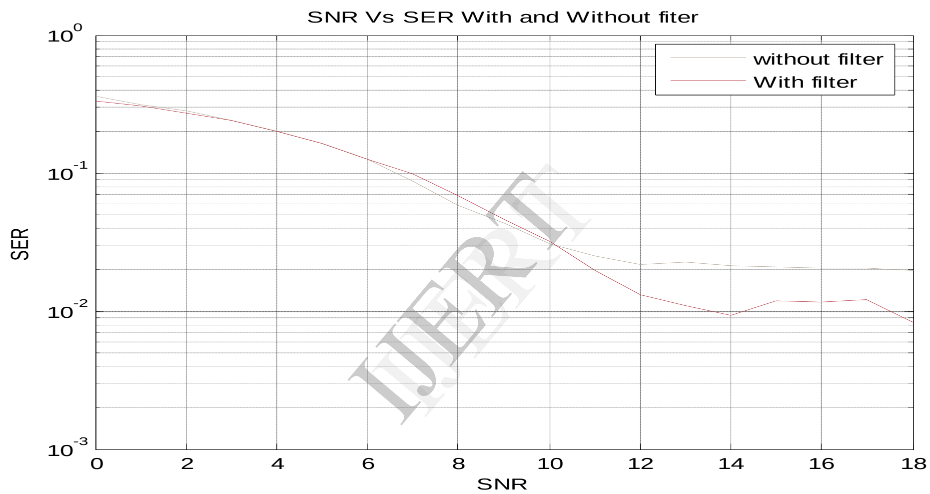

Fig.5.SER comparison with and without filter

Fig. 6.Compares the PAPR of Plain COFDM with and without Clippig OFDM baseband signal.And Fig.7 and Fig.8 gives the performance analysis of Iterative lipping and filtering.

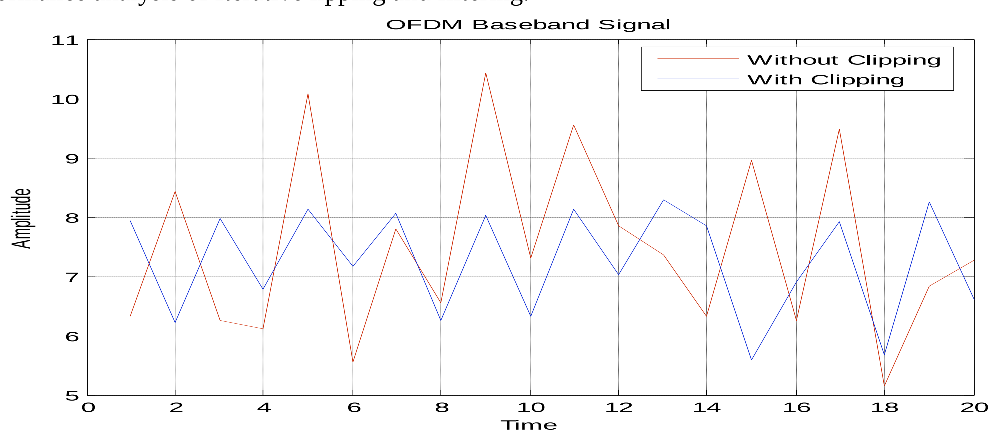

Fig.6.Clipping effect on amplitude of OFDM baseband signal

PAPR without iterative clipping=7.4946

PAPR with iterative clipping=7.2558

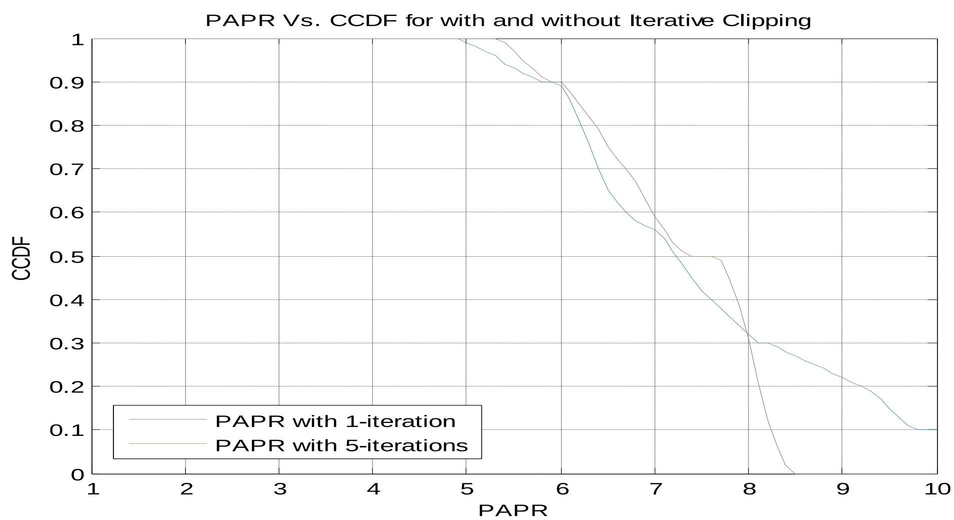

Fig.7.PAPR comparison of OFDM with and without ICF

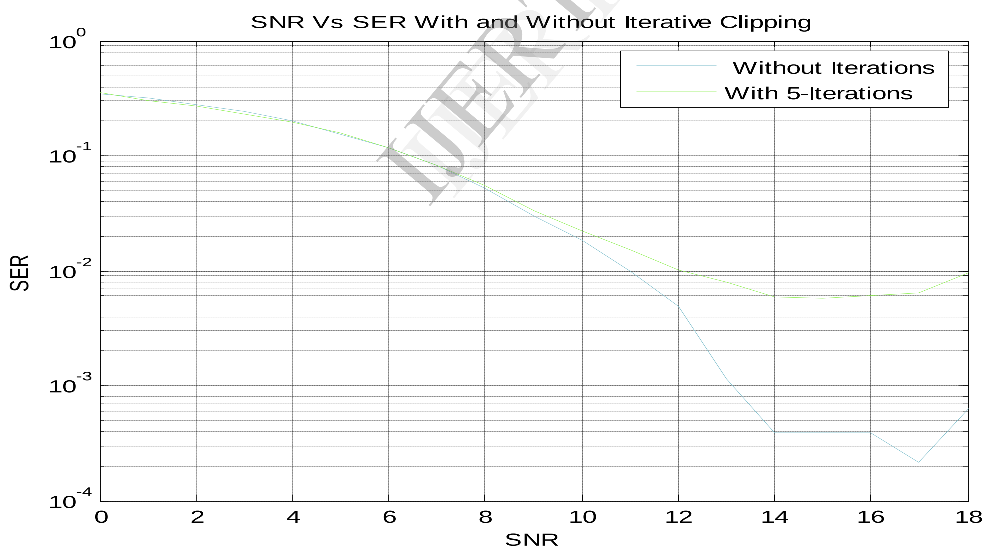

Fig.8.SER comparison of OFDM with and without ICF

6. Conclusion

In terms of PAPR analysis, the PAPR performance for post -clipped and filtered versions (modified) for convolution precoded system versions is better than unclipped versions. However this is achieved at cost of increase in complexity of circuit.

Results show that QAM scheme has best SER performance when iterations are increased.And also the filter reduces out-of-band distortion and PAPR.

7. References

[1] "An Investigation of Peak-to-Average Power Reduction in MIMO-OFDM Systems",Wang Yi Gu linfeng Blekinge Institute of Technology October 2009.

[2] Tao Jiang, Member and Yiyan Wu ,"An Overview: Peak-to-Average Power Ratio Reduction Techniques for OFDM Signals", IEEE TRANSACTIONS ON BROADCASTING, VOL. 54, NO. 2, JUNE 2008 257

[3] Xiao dong Li and Leonard J. Cimini, "Effects of Clipping and Filtering on the Performance of OFDM ," IEEE Communications Letters , Vol. 2, No. 5, May 1998.

[4] H. Ochiai and H. Imai, "Performance analysis of deliberately clipped OFDM signals," *IEEE Trans. Commun.*, vol. 50, pp. 89–101, Jan. 2002.

[5] S. H. Han and J. H. Lee, "An overview of peak-to-average power ratio reduction techniques for multicarrier transmission," IEEE Wireless Communications, vol. 12, issue 2, pp. 56- 65, April 2005.

[6] S. C. Thompson, J. G. Proakis, and J. R. Zeidler, "The Effectiveness of Signal Clipping for PAPR and Total Degradation Reduction in OFDM Systems," IEEE GLOBECOM, pp. 2807-2811, December 2005.

[8] J. Armstrong, "Peak-to-average power reduction for OFDM by repeated clipping and frequency domain filtering," IEE Electronics Letters, vol. 38, pp. 246-247, February 2002.