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A New Single Iterative Clipping and Filtering Technique to Reduce PAPR

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Abstract: - *Orthogonal Frequency division is an emerging modulation technique that provides high spectral efficiency and bandwidth. It has a drawback of high Peak to Average Power Ratio. In this paper we discuss a new clipping and filtering approach which is based on cancellation of clipping noise to overcome the drawback of PAPR in OFDM. This method requires only single iteration to resolve the problem of PAPR. The simulation shows that the QPSK modulated OFDM signal with 1024 subcarriers achieve a PAPR reduction to a 2dB.*
Keywords:-*OFDM (Orthogonal Frequency Division Multiplexing), PAPR (Peak to Average Power Ratio), Clipping, FFT (Fast Fourier Transform), CCDF*

I. INTRODUCTION

OFDM is a multicarrier modulation technique which can provide high data rate. Moreover it provides resistance to multipath fading, robust against narrow band co channel interference and can be efficiently implemented due to which it has become a promising technique in current communication system. The basic principle of OFDM is that the high data rate stream is split into a number of lower data rate stream that are simultaneously transmitted over a number of subcarriers. The carriers are made orthogonal by choosing appropriate spacing between them. Due to large number of subcarriers, OFDM has a drawback of large PAPR. Several techniques has been proposed in [1,2] to reduce PAPR like clipping and Filtering, Tone Reservation, SLM to reduce PAPR but we require the technique which is cost effective as well as have bandwidth efficiency. Among various techniques, the clipping technique has been widely used as a practical scheme owing to it low computational complexity and simplicity in implementation [10]. It is cost effective as well. It is simplest approach for reduction of PAPR in OFDM system. The amplitude of signal can be clipped to reduce peak power to a desired level before amplification. Clipping is nonlinear process and it may cause in band distortion and results in BER performance degradation. It also cause out of radiation which imposes out of band interference signals to adjacent carriers and thus causes spectral inefficiency. Filtering after clipping can reduce out of band radiation to maximum extent, but also produces some peak re growth in the filtered signal. Aliasing problem is faced in clipping after filtering which can be reduced by adding zeros in original input called zero padding. To improve the bit error rate and spectral efficiency some techniques can be used like Forward Error Correcting codes and band pass filtering with clipping [6]. . Furthermore, clipping of OFDM signals causes clipping noise which has sparsity in time domain. In this paper, we cancel this clipping noise after the filtrations, it solves the problem of peak re growth and also it requires single iteration to reduce PAPR as the increase in iterations increase complexity and reduction become slow after several iterations. The rest of the paper is organized as follows. The second section describes the OFDM signal and PAPR. The third section describes the proposed PAPR reduction scheme. Next, the numerical results in matlab are presented and discussed. Based on the results obtained, some conclusions are presented.

II. OFDM and PAPR

OFDM is a multicarrier modulation technique so a large number of subcarriers have been used to transmit the detain OFDM; it implies that the transmitter and receiver blocks become bulky and expensive to build. Also the oscillators (for generating the carrier frequencies) have temperature instability. The OFDM modulation and demodulation can be accomplished using the computationally efficient operations- IFFT and FFT respectively. Since OFDM signal consists of a number of independently modulated sub-carriers, which can give a large PAPR when added up coherently. When N signals are added with the same phase, they produce a peak power that is N times the average power of the signal. So OFDM signal has a very large PAPR, which is very sensitive to non-linearity of the high power amplifier.

$$x(t) = \frac{1}{\sqrt{N}} \sum_{n=0}^{N-1} X_n \cdot e^{j2\pi n\Delta ft}, 0 \le t \le T$$

PAPR is defined as the large variation or ratio between the maximum power and the average power [1, 2].

$$PAPR = \frac{\max_{0 \le t \le T} |x(t)|^2}{1/T \cdot \int_0^T |x(t)|^2 \, dt}$$

To measure the performance of PAPR CCDF (Complementary Cumulative Distribution Function) is used. It denotes the probability that PAPR of data block exceeds a given threshold. . If the CCDF graph is plotted against the threshold values, the more vertical the graph is, the better is the PAPR reduction performance.

III. PROPOSED METHOD

Clipping and filtering is simple and basic technique performed digitally on an oversampled signal. In real system, the Oversampling is needed since the PAPR of digital signal is not the same as the PAPR of the analog signal. If we clip the oversampled signal, distortion noise also falls in the out of the given band, called spectral leakage [10]. The spectral leakage degrades the performance of adjacent channels, but it can be reduced by filtering after clipping [3, 4].To suppress peak re growth due to filtering, iterative clipping and filtering (ICF) techniques can be used [8,13] but the convergence rate decreases significantly after the first few iterations[9]. Note that each iteration requires two fast Fourier transform/inverse fast Fourier transform (FFT/IFFT), and after the last iteration, one extra IFFT is required to convert the clipped OFDM symbol to time domain. As a K-iteration process requires (2K+1) FFT/IFFT, the increased number of iterations implies increased computational complexity, especially when the number of subcarriers is very large [3]. This method requires three fast Fourier transform (FFT)/inverse fast Fourier transform IFFT operations while the conventional CF method requires (2K+1) FFT/IFFT operations, where K refers to the number of iterations. The simulation result shows that the QPSK modulated OFDM signal with 1,024 sub-carriers achieves a PAPR reduction of 2 dB. Clipping to reduce PAPR introduce distortion and the signal distortion introduced by clipping operation can be reduced by applying a low pass filtering operation on the clipped signal. However repeated clipping and filtering operation with K iterations requires (2K+1) an FFT/IFFT operation [3] which makes computably complexity. According to Price's theorem, the clipping operation can be modeled as a linear process xn^ =xn+α*d **,**where α is attenuation factor, d is added noise. The total clipping noise after K iterations is calculate based on the clipping noise generated after first iteration which is expressed by the parameter β as:

$$\beta = \frac{1-(1-\alpha)^{3k/2)}}{1-(1-\alpha)^{3/2}}$$

The figure1 shows the block diagram of proposed clipping and filtering algorithm with noise cancellation at last. The algorithm can be stated as follow:

1. The frequency domain OFDM signal is padded with (L-1)N zeros, L is the oversampled value.
2. Compute time domain signal by applying IDFT on step 1
3. Perform clipping operation to a threshold value
4. Determine clipping noise which is the difference of original and clipped signal.
5. Transform the noise in frequency domain
6. Compute the clipped OFDM signal which is subtraction of frequency domain OFDM signal and β noise in frequency domain.
7. Compute IDFT on step6 to obtain time domain clipped OFDM signal.
8. Filtration is applied to remove out of band radiation.
9. Cancel the clipped noise by subtracting the above from expected value of noise in time domain

With subcarriers of 1024 and oversample factor, L=4 and FFT size 4096 and using clipping and filtering algorithm with noise cancellation of clipping noise, we get PAPR reduction up to 2dB.

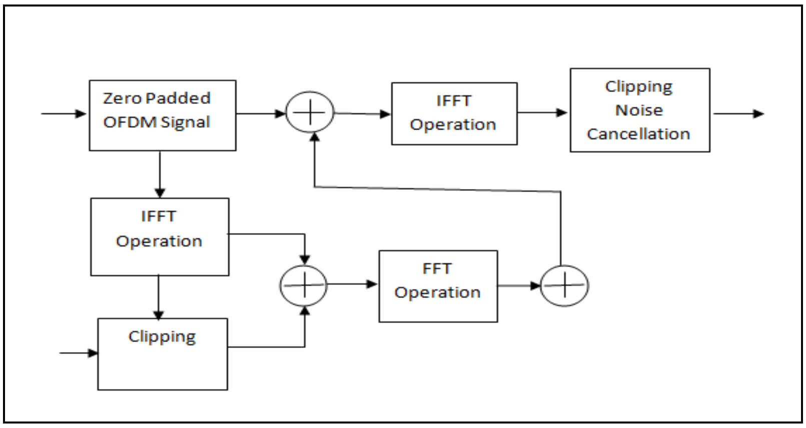

Fig.1: Block Diagram of Proposed Method

IV. SIMULATION AND RESULTS

The MATLAB simulations have been performed with subcarriers=1024 using QPSK modulation with oversampling factor, L=4 and corresponding constellations having M=4 points. For the clipping block was considered a clipping rate CR set to 1.4 and clipping threshold to 6dB. The low pass Butterworth filter is used having order of 2 and cut off frequency Wn=0.5 The fig.2 shows the simulation result for the basic clipping and filtering method to reduce PAPR which shows the reduction up to 12 dB only.

The clipping noise is then cancelled from clipped and filtered OFDM signal which shows significant reduction of PAPR. The figure3(a) shows comparison of CCDF of original OFDM signal with the CCDF by applying proposed clipping and filtering algorithm. The result shows that PAPR is reduced to 5 dB using the proposed algorithm. The PAPR reduction is significantly shows the better result with the cancellation of clipping noise after clipping and filtering as shown in fig. 3(a) and figure 3(b). Thus elimination of clipping noise at the transmitter reduces the in-band distortion and demands no additional complexity at the receiver. If we increase the cut off frequency of the filtering operation used that is if the Wn=0.9, we get the reduction up to 2dB which is a great reduction in PAPR as shown in fig 3(b).

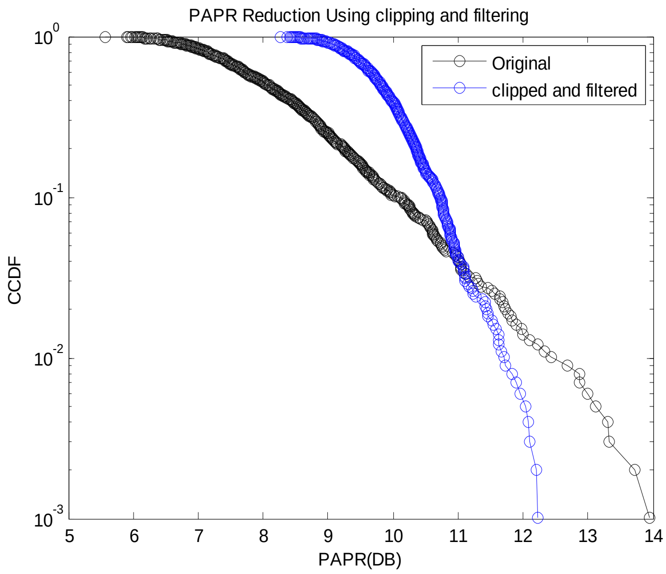

Fig.2:- PAPR reduction using conventional Clipping and filtering

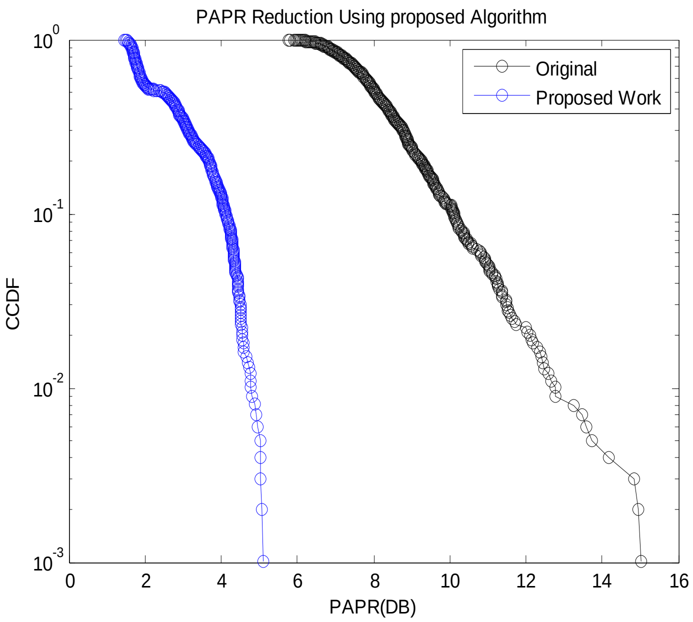

Fig 3(a) PAPR reduction using proposed method

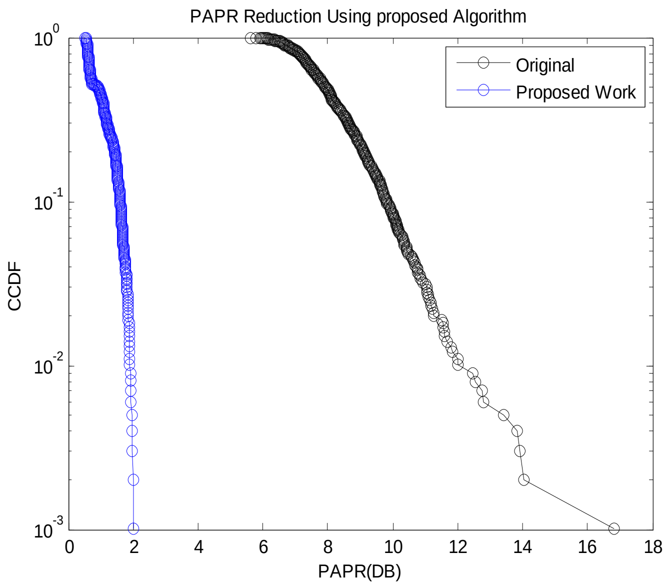

Fig 3(b) PAPR reduction using proposed method

V. CONCLUSION

In this, a non-iterative clipping and filtering algorithm employing a clipping noise cancellation technique is proposed and its performance in terms of PAPR reduction. This algorithm attains a 6 dB reduction in PAPR. The computational complexity of this algorithm is less compared to other Clipping and Filtering techniques. Elimination of clipping noise at the transmitter reduces the in-band distortion and demands no additional complexity at the receiver. The CF algorithm achieves PAPR reduction by 50 % when compared to the original OFDM signal. The proposed algorithm can be used to optimize OFDM systems by employing pre-distortion with noise cancellation such that PAPR is reduced and is more appropriate for real time applications.

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