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A Hybrid Approach using CF and SLM Technique with Cancellation of Noise to Reduce PAPR

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Abstract:
Orthogonal Frequency division is a rising modulation technique that can provide high spectral efficiency and bandwidth and it has been under research for wireless communication owing to its toughness against multipath fading. It faces a disadvantage of high Peak to Average Power Ratio. In this paper we discuss a joint clipping and filtering and SLM approach which is based on cancellation of clipping noise to overcome the drawback of PAPR in OFDM. This method requires only single iteration of clipping and filtering method with the conventional Selective mapping technique to resolve the problem of PAPR. The simulation result shows that the QPSK modulated OFDM signal with 1024 subcarriers achieve a PAPR reduction to a 2.5dB with this approach.

Keywords: PAPR (Peak to Average Power Ratio), OFDM (Orthogonal Frequency Division Multiplexing), Clipping, FFT (Fast Fourier Transform), CCDF, SLM.

I. INTRODUCTION

OFDM has been a recently used high data rate multicarrier modulation technique. It gives resistance to multipath fading and moreover provides robustness 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 main principle of OFDM is that the high data rate stream is divided into a large number of lower data rate streams that are simultaneously send over a number of subcarriers. The carriers are made orthogonal by selecting appropriate spacing between them. Due to large number of subcarriers which are usually in 1000s, 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 a technique which is having cost effectiveness as well as have bandwidth efficiency. The clipping technique has been widely used as a practical scheme owing to it low computational complexity and simplicity in implementation among various techniques [10]. It is cost effective as well. It is the simplest technique for reduction of PAPR in OFDM system. The signal's amplitude can be clipped to reduce peak power to a considered necessary level before amplification. Clipping is nonlinear process and it may cause in band distortion which can results in BER performance degradation. It also causes out of radiation which cause out of band interference signals to adjacent carriers and thus causes spectral inefficiency. Filtering after clipping can overcome with the problem of out of band radiation to maximum extent, but also produces some peak re growth in the filtered signal. After filtering aliasing problem is faced in clipping which can be decreased by addition of zeros in original input which is known as 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, the clipping of OFDM signals causes clipping noise which has sparsity in time domain. Among various schemes, the clipping technique has been considered as the most practical solution and widely used owing to its non-expansion of bandwidth, low computational complexity and simplicity in operation without receiver-side cooperation and the selected mapping (SLM) technique is known to provide good PAPR reduction performance without signal distortion [13]. The combination of two PAPR reduction techniques, which are the clipping and the SLM, is likely to provide the enhanced performance of PAPR reduction [10], because the clipping noise of combined scheme would be less than that of single clipping technique, when the SLM technique is employed after clipping and then filtered. 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 of clipping and filtering 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 fulfilled by using the computationally efficient operations- IFFT and FFT respectively. Since OFDM signal have a large number of independently modulated sub-carriers, which can give a large PAPR when coherently added up. A peak power is produced When N signals are added with the same phase, that power is N times the average power of the signal[2]. So OFDM signal has a very large PAPR, which provides very sensitivity to non-linear nature of the high power amplifier.

$$x(t) = \frac{1}{\sqrt{N}} \sum_{n=0}^{N-1} x_n e^{j2n\Delta ft} \;; \quad 0 \le t \le T \qquad (1)$$

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

$$PAPR = \frac{max|x(t)|^2}{{}^1/_T \int_0^T |x(t)|^2\, dt} \qquad (2)$$

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

III. CLIPPING AND FILTERING TECHNIQUE

Clipping and filtering is simple and basic technique performed digitally on an oversampled signal. In real system, the Oversampling is required since the PAPR of digital signal is not the similar to the PAPR of the analog signal. The distortion noise also falls in the out of the given band, called spectral leakage if we clip the oversampled signal [10]. The spectral leakage reduce the performance of adjacent channels, but it can be enhanced 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 6 dB with only clipping and filtering technique with noise cancellation. The block diagram shows the clipping and filtering with elimination of noise.

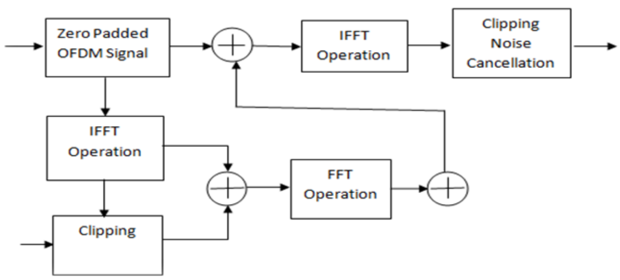

Figure.1. Block Diagram of Clipping and Filtering using noise cancellation

IV. PROPOSED METHOD

An OFDM has been implemented with the hybrid scheme of clipping and SLM technique to reduce PAPR in OFDM. The clipping noise is also cancelled in the proposed method .The elimination of clipping noise cause reduction in band distortion. The total clipping noise after K iterations is calculated s based on the clipping noise generated after first iteration which is expressed by the parameter β as:

$$\beta = \frac{1-(1-\alpha)^{3k/_2})}{1-(1-\alpha)^{3/_2}} \qquad (3)$$

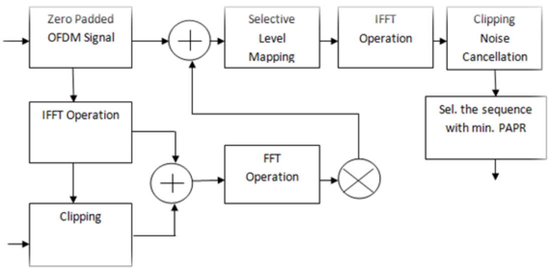

Figure.2. Block diagram of a Hybrid approach using CF and SLM technique with cancellation of noise to reduce PAPR

The figure-2 shows the block diagram of proposed method 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. Apply SLM technique on the clipped OFDM signal.
8. Compute IFFT on the signal obtained from step 6.
9. Filtration is applied to remove out of band radiation.
10. 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 with SLM technique after clipping algorithm with noise cancellation of clipping noise, we get PAPR reduction up to 2.5dB.

V. 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. The cumulative distribution function is the mostly used parameter for measuring the efficiency of PAPR technique. However complementary CDF is used instead which help us to measure the probability that the PAPR of a certain data block exceeds the given threshold. 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.3 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 figure4 shows comparison of CCDF of original OFDM signal with the CCDF by applying clipping and filtering algorithm with noise cancellation. The result shows that PAPR is reduced to 5 dB using this method as shown in figure 4. The elimination of clipping noise makes a significant reduction of in band distortion which is the major problem of clipping Thus elimination of clipping noise at the transmitter reduces the in-band distortion and demands no additional complexity at the receiver. Selective Level Mapping is applied to this clipped signal to get the maximum reduction in PAPR whose algorithm is discussed above with the subcarriers=1024 using QPSK modulation with oversampling factor, L=4 and corresponding constellations having M=4 points. The combination of SLM with clipped signal shows the better result if compared to the individual technique by considering the same parameters. The signal with minimum PAPR is transmitted. Figure5 shows the reduction to 2.5dB. Eb/N0 denotes the Carrier to noise ratio. BER is degraded at the receiver due to the in-band distortion contributed by the clipping process [3]. The elimination of clipping noise in the paper results in significant reduction of in-band distortion and there is improvement in BER performance which is illustrated in the simulation result shown in Fig. 6. Moreover the BER performance of clipping and filtering with noise cancellation and its hybridization with SLM is compared with original OFDM signal which shows that the method in this paper shows the reduction in BER.

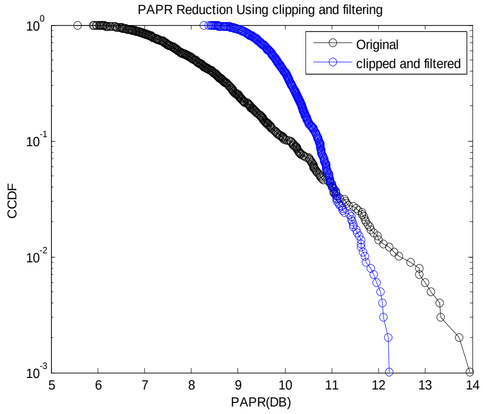

Figure. 3. CCDF of the PAPR for the clipping and filtering method

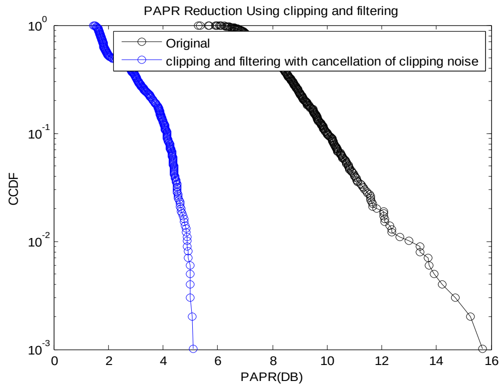

Figure. 4. CCDF of the PAPR for the clipping and filtering method with cancellation of noise

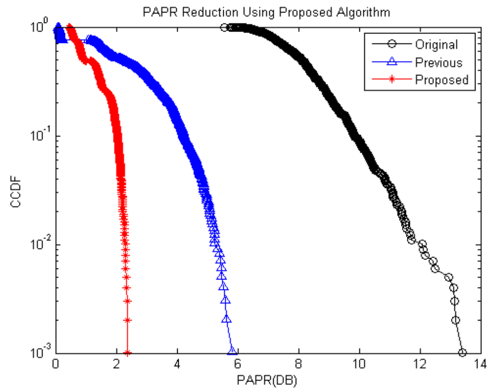

Figure. 5. CCDF of the PAPR for Clipping and Filtering with SLM

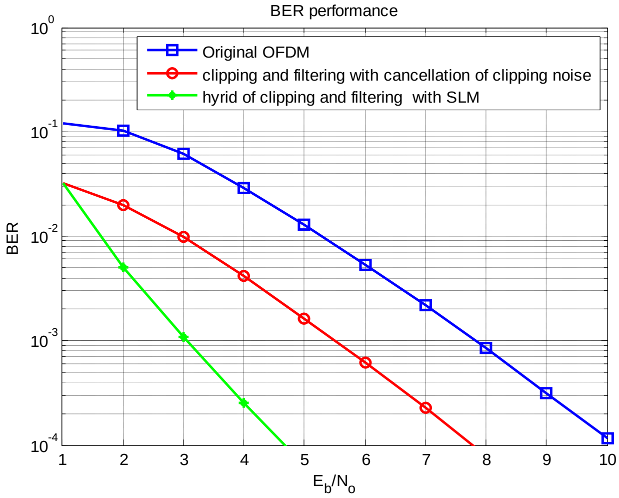

Figure. 6. Comparison of BER Performance

VI. CONCLUSION

In this paper, a non-iterative clipping and filtering algorithm with SLM technique is employing a clipping noise cancellation technique is proposed and its performance in terms of PAPR reduction and BER is presented. This algorithm attains a 2.5 dB reduction in PAPR and this algorithm has less computation as compared to other Clipping and Filtering techniques. Elimination of clipping noise at the transmitter decreases the in-band distortion and it requires no additional complexity at the receiver.

VII. FUTURE WORK

The reduction in PAPR increases the performance of OFDM. So that further improvement of the system, the OFDM signal can be transmitted to different channel. The 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. This method can be further extended to estimate its performance over fading and Stanford University Interim channel models.

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