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Analysis of PAPR Reduction Techniques in OFDM

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Abstract

Presently, orthogonal frequency division multiplexing (OFDM) as a multicarrier transmission system is widely used. Along with its advantages it has many disadvantages. One of its major drawback is high peak to average power ratio (PAPR). As with high PAPR the spectral efficiency of the high power amplifiers degrades. So it becomes necessary to maintain the efficiency of a wireless system to reduce the PAPR radio. To reduce the PAPR there are many techniques such as Clipping & filtering technique, selective mapping, tone reservation and partial transmit sequence. In this paper, the main focus is on clipping & filtering technique and partial transmit sequence. A general comparison between these two techniques has been done.

Keywords: OFDM, PAPR, BER, SNR, CCDF.

I. INTRODUCTION

In Recent times, the interest for multimedia applications has developed very rapidly which drive us in the period of fourth generation of wireless communication system. When there are a large number of user and the spectrum is very limited then it becomes essential for wireless communication system to choose such technologies that can utilize the spectrum efficiently and can serve maximum users. Along with serving maximum users, major aim is to achieve robustness to multipath channel environment and bandwidth efficiency. Multicarrier wireless communication system has the capability to provide high speed data rate for maximum users at very low cost. [1] Major difference between single carrier system and multicarrier system is that in single carrier system the entire bandwidth is occupied by one carrier and in multicarrier system the bandwidth is divided among many carriers with each sub

carrier having smaller bandwidth. OFDM has feature of multicarrier system so it becomes interesting to study about OFDM. OFDM frames reason for every 4G wireless communication frameworks because of its huge limit regarding number of subcarriers, high data rate in overabundance of 100 Mbps and high versatility. Along with the advantages of OFDM , it has one major drawback of high PAPR (peak-to-average power ratio). In this paper, the various techniques of OFDM for PAPR reduction has been discussed.

II. PEAK TO AVERAGE POWER RATIO(PAPR)

OFDM signal has a very special feature that it comprises of various independent modulated subcarriers which have different phases and amplitudes. These subcarriers possess distinctive spectra in the frequency area and are transmitted exactly at the same time [9]. At the point when those subcarriers are summed up, the prompt peak power of an OFDM signal will be much greater than the average power, which results in a large PAPR (peak-to-average power ratio).

Disadvantage of large peak to average power ratio is that it reduces the efficiency of radio-frequency power amplifiers.

The other major disadvantage of high PAPR is that it increases the complexity of convertors that are used for analog to digital and digital to analog conversion purpose.

Expression to show PAPR in OFDM signal is [11]:

$$\mathbf{PAPR} = \frac{\mathbf{max}[x(t)]^2}{E\{|x(t)|^2\}} \quad (1)$$

III. LITERATURE REVIEW

Here are the literature review of some papers.

Analysis and comparison of clipping techniques for OFDM peak to average power ratio reduction

In this paper, the author has discussed about the major disadvantage i.e. high Peak to average power ratio of OFDM. High PAPR can reduce the efficiency of High power amplifiers. The simplest PAPR reduction technique clipping technique has been discussed in this paper. There are four types of clipping techniques; Heavyside clipping, deep clipping, Classical clipping and smooth clipping that have been implemented in this paper. According to results, Deep clipping seems to be best of the four in terms of overall flexibility, average power variations, and total system degradation.[3]

Clipping and filtering technique for reducing PAPR in OFDM

In this paper, author has discussed about both the advantages and disadvantages of orthogonal frequency division multiplexing (OFDM). OFDM as a multicarrier

transmission performs better than single carrier transmission system as single carrier transmission has major disadvantage of complexity of equalizer. This complexity is directly proportional to the data rate. In this paper main focus is on PAPR reduction technique of OFDM as well as on the Bit error rate (BER) performance.[4]

PAPR reduction of OFDM signals using PTS: a real-valued genetic approach

Partial transmit sequence (PTS) as a Peak to average power ratio (PAPR) reduction technique of orthogonal frequency division multiplexing (OFDM) works very efficiently. In this paper, the working of PTS technique has been discussed. Partial transmit sequence technique searches all possible rotation phase combinations. As it looks for all the possible combination so the computational complexity of the overall system increases significantly. To reduce PAPR and computational complexity many researchers suggested some algorithms named as binary-coded genetic algorithms. To further decrease the PAPR of OFDM signal, this paper suggests one refined PTS method named as real-valued genetic algorithm (RVGA). One cost function is decided that too depends upon the amount of peak to average power ratio. This new PTS approach works as optimization solution. In this paper, the results shows that RVGA is not able to make any improvement in PAPR but it is able to reduce the overall computational complexity.[6]

Partial transmit sequence (PTS) –PAPR reduction technique in OFDM systems with reduced complexity

In this paper, the author has discussed about the peak to average power ratio. In a non-linear region of amplifiers, the sub-carriers of OFDM operates in large dynamic range and suffer from high PAPR. Due to high PAPR component cost increases. In this paper, by reducing the complexity of IFFT architecture, the PAPR of OFDM Signal reduction scheme has been discussed. There are a lot of unnecessary multiplications and additions with zero in IFFT architecture. By eliminating these unnecessary additions and multiplications, computational complexity can be reduced. This will not lead in any change in resulting signal. In this paper, PTS sub-block PAPR reduction methods has been discussed and analyzed.[2]

Clipping technique for BER and PAPR reduction in OFDM system

Power degradation and spectral spreading are the two main issues that are caused due to high Peak to average power ratio of OFDM. In this paper, simplest kind of technique; clipping technique has been discussed for PAPR reduction. This technique looks to be very effective for commercial system. Two methods Amplitude clipping and filtering method has been focused in this paper. With different clipping ratios, the author shows various simulation results of PAPR and BER performance with clipping and filtering method. [5]

IV. PAPR REDCUTION TECHNIQUES

There are many PAPR reduction techniques but in this paper, main focus is on clipping & filtering technique and partial transmit sequence.

A. Clipping & filtering technique

To reduce the peak to average power ratio, clipping technique works as the simplest method. It is based on the idea that it sets threshold level for the transmitted signal [10]. so the components of signal that are out of band i.e. that are above than threshold value are clipped and components below the threshold level are considered for further processing. Thus PAPR ratio can be given as [4]:

$$Y_k = \begin{matrix} X_k, \ k \in I \\ 0, \ \ k \in 0 \end{matrix} \qquad (2)$$

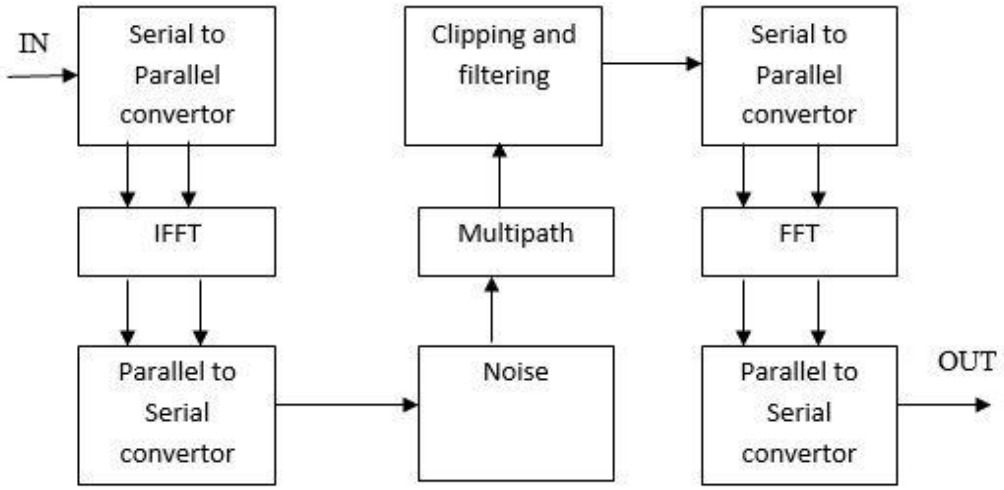

Figure 1: Block diagram of Clipping & filtering technique

However this technique is the simplest amongst all the techniques but it has some disadvantages [5]:

1. The FFT and IFFT block combine as filter in the block diagram of clipping technique results in increment of overall complexity of clipping technique. However this problem can be controlled by replacing this combination of FFT and IFFT block with implementation of out of band filter via a low pass filter.
2. BER performance can be degraded as clipping can cause in-band signal distortion.

3. Filtering is performed in the clipped signal, it can definitely results in reduction of out of band radiations but also it increases the peak re-growth.
4. With adjacent channels, out of band radiations cause interference.

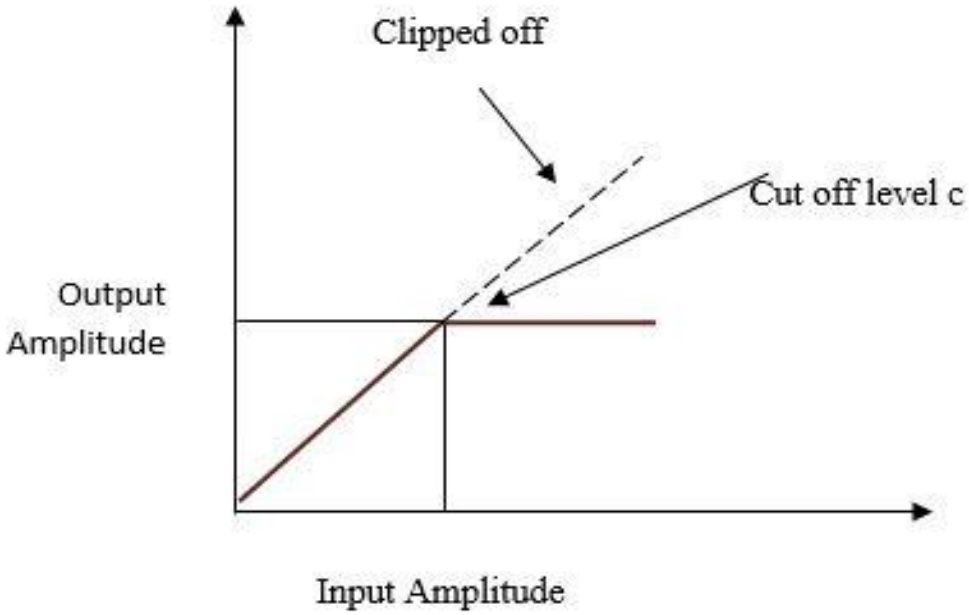

Figure 2: Clipping method

It is clear from the figure that when signal is above the cut off level c (threshold level) then it is clipped. The clipped signal can be expressed in mathematical terms as [12]:

$$x(n) = \begin{cases} |x(n)| & if\ |x(n)| \leq C(threshold) \\ C & if\ |x(n)| > C(threshold) \end{cases} \quad (3)$$

B. Partial transmit sequence

Partial transmit sequence technique is based on the idea that it transmit only those part of signal which carries actual information of the sub-carriers [9]. In partial transmit sequence, the input data vector is first divided into m disjoint blocks then each block is multiplied by some random vectors. This is done to reduce the PAPR. This random vector is generated by phase factor optimizer. So that value will be considered that can lead to reduction in PAPR. Partial sub blocks are in time domain then these blocks are combined after independently multiplied by phase factor to produce OFDM symbols with lesser PAPR in time domain.

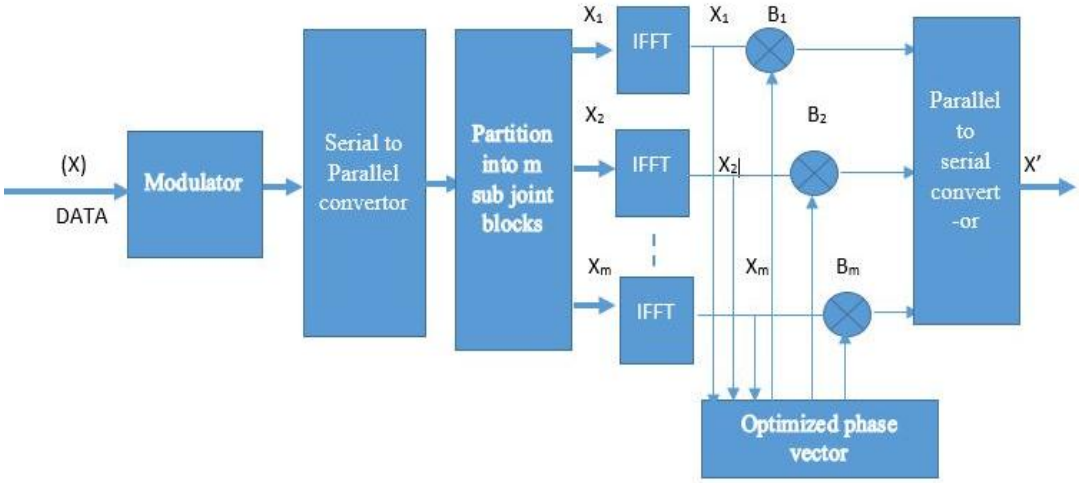

Figure 3: Block diagram of PTS technique [7].

In mathematical terms, PTS can be expressed as:

Let input data vector X is divided in m sub-joint vectors, these sub-joint vectors can be represented as $\{X_v, v=1,2,3\ldots m\}$

In other words,

$$X = \sum_{V=0}^{V-1} X_v \tag{4}$$

At the time of partitioning of input data vector, the main focus is on size of block. Each block should be same in size.

There are various methods by which input vector can be partitioned:

1. Each block has same size.
2. Pseudo-random partition
3. Interleaved partition
4. Adjacent partition

V. COMPARISON OF PAPR REDUCTION TECHNIQUES

Comparison of all the PAPR reduction techniques can be done by analyzing the graphs. Along with PAPR, two more parameters are there that can be considered for comparison purpose. These two parameters are SNR and BER, where BER stands for bit error rate; it is the rate at which at the time of transmission of digital data error occurs [8]. While SNR stands for signal to noise ratio; it is the ratio of actual desired signal to the unwanted noise.

C. Comparison based on PAPR value:

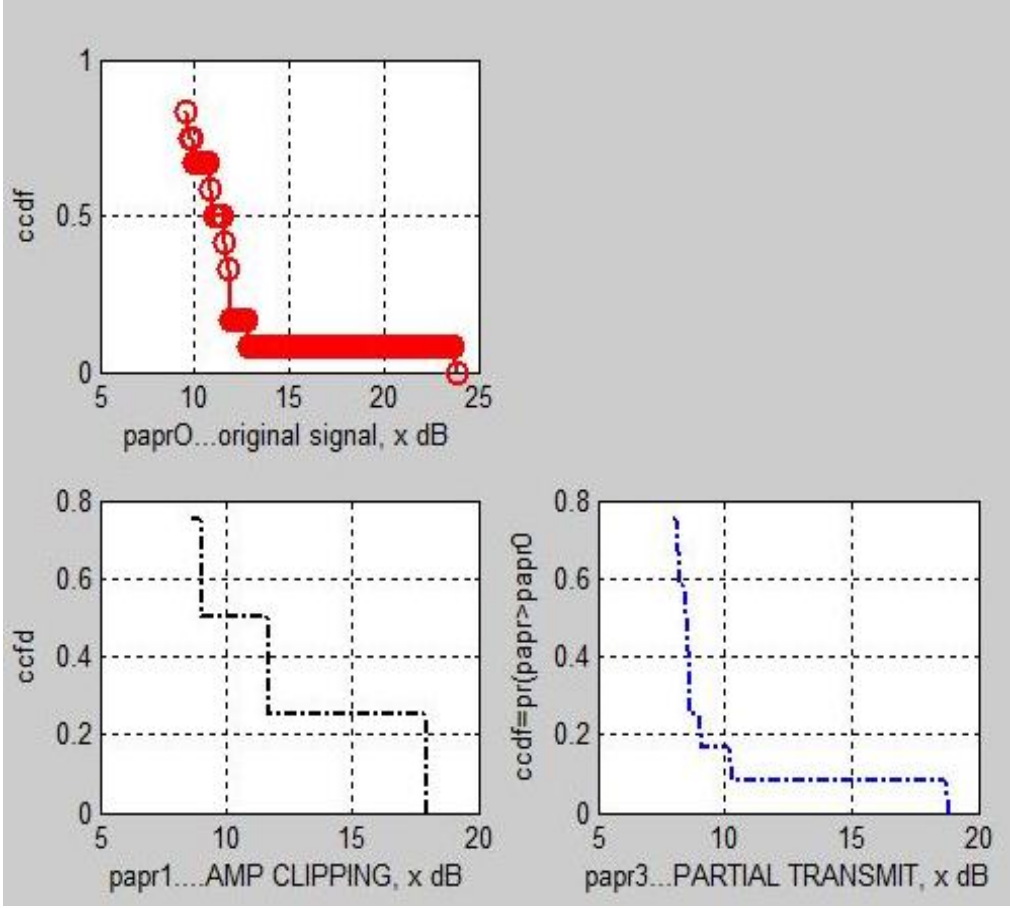

Figure 4: Graph of PAPR vs ccdf with original signal, clipping method, PTS technique. The value of IFFT bit length is 1024, carrier count is 123, bits per symbol value is 5, SNR value is 12 and symbols per carrier value is 12 .

Above graph shows the original signal with 'papr0.original signal' on x axis and 'ccdf' on y axis. Here ccdf represents the complementary cumulative distribution function. It is clear from the graph that the value of Peak to average power ratio i.e. PAPR is 24 dB.

The graph with clipping technique is with 'papr1. AMP CLIPPING' on x axis and 'ccdf' on y-axis. Here the PAPR has been reduced to 18 dB.

The graph with partial transmit sequence is with 'papr3.partial transmit sequence' on x-axis and 'ccdf' on y-axis. The PAPR with this technique comes out to be 19 dB.

D. Comparison based on BER and SNR value:

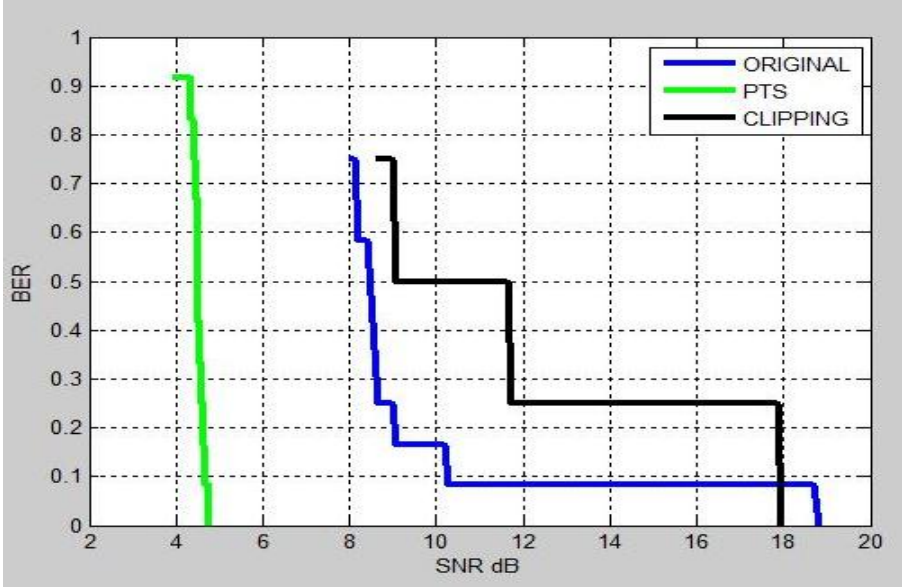

Figure 5: Graph of BER vs. SNR for original signal, clipping method, PTS technique.

The graph represents the bit error rate and signal to noise ratio with SNR on x axis and BER on y-axis. From the graph it has been shown that the partial transmit sequence turns out to be best among the PAPR reduction technique as clipping technique and original signal. Value for PTS is near to 4.5. For Clipping and original signal method the value comes out to be 18 and 19 respectively.

CONCLUSION

In this paper, the PAPR reduction techniques has been discussed. The main focus in this paper is on Clipping & filtering method and partial transmit sequence. The PAPR of the OFDM signal can be decreased significantly with these techniques. The analysis graph shows that the PAPR can be reduced more effectively with clipping & filtering technique. But the graph between BER and SNR shows that the value is less for partial transmit sequence, BER ratio is worse in original signal. By analysis these technique it has been concluded that the PAPR performance improves with these techniques but it can be improved even more by optimizing these techniques.

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