An Improved Active Constellation Extension Approach for PAPR Reduction in OFDM System

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Abstract— **Orthogonal Frequency Division Multiplexing (OFDM) is a spectrally efficient multicarrier modulation technique for high speed data transmission over multipath fading channels. Along with number of advantages of using OFDM there are some issue such as the transmitted signals get suffered from high Peak-to-Average Power Ratio (PAPR). Different researchers have proposed various techniques to handle the above mention problem but that leads to the increment in the complexity of the system, higher Bit error rate (BER) and transmitted signal power, etc. In order to get rid of the above defined issues a novel Active Constellation Extension (ACE) method has been proposed that gives better results in terms of various performance parameters like PAPR and BER but there was a issue of disturbance in adjacent channel due to use of clipping technique for power reduction in initial stage.**
So, in this study we have proposed a new scheme in which the clipping technique is used to clip both sides of the signals. Along with this the signal filtration is also performed so that the more smooth signals can be obtained. As, it has been concluded from survey that among different PAPR reduction techniques, clipping is found to be an effective technique which can reduce PAPR to an extent. The Matlab is used for analyzing the proposed scheme that gives better results in terms of both PAPR and BER.
Keywords— OFDM, PAPR, BER, convex optimization, clipping.

I. INTRODUCTION

Orthogonal Frequency Division Multiplexing (OFDM) is a multicarrier modulation technique which segregates the accessible spectrum into subcarriers, among every subcarrier attaining a low rate data stream. As illustrated in the figure 1.1 to achieve the orthogonality the proper spacing is attained by the subcarriers and the pass-band filter shape. The orthogonality for a couple of signals can be numerically stated as:

$$\frac{1}{T}\int_{t_1}^{t_2+T} f_k(t)\times f_l(t)dt = 0 \; if \; k \neq l \qquad (1.1)$$

Where $f_k(t)$ and $f_l(t)$ are any two signals over time period $[t_1, t_1+T]$, T is a signal time interval. For orthonormal, the time averaged integral product of two should be one.
Mathematically, ortho-normal of two signals can be written as-

$$\frac{1}{T}\int_{t1}^{t1+T} f_k(t) * f_l(t)dt = 1 \quad if \; k = l \qquad (1.2)$$

By applying equation (1.1) and (1.2), orthogonality for OFDM system is written as-

$$\frac{1}{T}\int_0^T e^{j2\pi f_k t} * e^{-j2\pi f_l t}\, dt = \frac{1}{T}\int_0^T e^{j2\pi kt} \times e^{-j2\pi lt}\, dt = \frac{1}{T}\int_0^T \frac{e^{j2\pi(k-l)t}}{T} dt \qquad (1.3)$$

By resolving equation(1.3), we get-

$$\frac{1}{T}\int_0^T e^{j2\pi f_k t} \times e^{-j2\pi f_l t} = \begin{cases} 0 & \forall\, k \neq l \\ 1 & \forall\, k = l \end{cases} \qquad (1.4)$$

Taking the discrete samples with the sampling instances a t $t = nT_s = {nT}/{N}, n = 0,1,2\ldots$..N-1. Equation (1.4) can be expressed in discrete time domain as-

$$\frac{1}{N}\sum_{n=0}^{N-1} e^{\frac{j2\pi k}{T} nT_s} * e^{-\frac{j2\pi k}{T} nT_s} = \frac{1}{N}\sum_{n=0}^{N-1} e^{\frac{j2\pi(k-l)}{N} n} = \begin{cases} 0 & \forall\, k \neq l \\ 1 & \forall\, k = l \end{cases} \qquad (1.5)$$

The whole bandwidth is decomposed into various restricted sub-channels and the information data is transmitted parallel in the OFDM mechanism. The several advancements of this system are like immunity to impulse interference, high spectral effectiveness and the frequency selective fading with having no powerful channel equalizer. As it has advantages this system also has a major demerit that is the high PAPR in the OFDM system. Due to having a large number of independent modulated subcarriers the issue of PAPR takes place. The high peak amplitude signal with decreasing no peaks is not possible to transmit it to the transmitter. Therefore, earlier than transmitting the high peak amplitude of the signals has to be decreased.

II. PROBLEM FORMULATION

In OFDM modulation, the high peak-to-average power ratio (PAPR) of transmitted signal because of the superposition of many subcarriers is one of the major problems. Due to the rise of PAPR in the signal the quality of the signal is degraded, also the complexity is increased in the analog to digital and digital to analog converter. So there is a need to reduce the effect of PAPR, Many techniques have been suggested for PAPR reduction, with different levels of success and complexity. Techniques like filtration, PTS etc were proposed but these techniques achieve PAPR reduction at the expense of transmit signal power increase, bit error rate (BER) increase, data rate loss, computational complexity increase, and so on. So there is need to proposed some other techniques that can reduce PAPR to a great extent, by studying previous PAPR reduction techniques, a new technique is proposed in this paper. From the literature survey, it has studied that use of traditional methods for reduction of PAPR does not provide better and recommended results. Due to which it should be replaced with the quality oriented technique to improve the results. In the conventional methods, single threshold value is used on which basis data clipping has done. But it suffers from the problem of upper part clipping as only single threshold value is used. Another backlog of traditional technique was that after performing the clipping to the signal, it leads to the distortion in signals. Consequently, in order to remove these issues from the conventional methods, new methods are proposed.

III. PROPOSED WORK

In OFDM modulation, the high peak-to-average power ratio (PAPR) of transmitted signal due to the superposition of many subcarriers is one of the major problems. Due to the rise of PAPR in the signal the quality of the signal is degraded, also the complexity is increased in the analog to digital and digital to analog converter. So there is a need to reduce the effect of PAPR, Many techniques have been suggested for PAPR reduction, with different levels of success and complexity. Techniques like clipping ,filtration ,PTS etc were proposed but these techniques achieve PAPR reduction at the expense of transmit signal power increase, bit error rate (BER) increase, data rate loss, computational complexity increase, and so on.

As in the problem formulation, it concludes that single threshold value cannot clip upper and lower data simultaneously. Due to which double threshold value is used in the proposed work to clip both parts of the data. Secondly, the filtration is applied to the signals, so that the distortion from them can be removed. Thus the proposed work has the capability to overcome the issues of traditional techniques for reducing the PAPR. The techniques used for proposed work are as follows:

a. N- Point FFT

The OFDM system is highly relies upon the concept of IFFT to achieve more effective and efficient performance related to the modulation at transmitter. Similarly, the FFT is used at the receiver side for demodulating the signals. To apply the IFFT/FFT in OFDM system is the most intensive and complex part to implement. Thus, the IFFT/FFT should be implemented in an optimized way to enhance the performance at fewer penalties. This study implements the FFT/IFFT modulation to modulate the signals.

b. Clipping

In OFDM the more usual issue is high PAPR. The demerits occur due to PAPR such as the enlarged complication of the DAC and ADC and also the decreased effectiveness of radio frequency power amplifier. Clipping is the easiest and efficient PAPR reduction mechanism that terminates the signal elements that goes beyond any unchanging amplitude known as clip level. Therefore, the distortion power is yielded by the clipping that is known as clipping noise and the signal spectrum that is broadcasted is extended that origins interfering. The in-band noise distortion is occurred by the nonlinear procedure that is clipping. In the functioning of the bit error rate and the out-of-band noise the degradation occurs that minimizes the spectral effectiveness. In eliminating elements of the enlarged spectrum the clipping and the filtering mechanism is efficient. Though the spectrum growth can minimize by the filtering, the out-of-band radiation can decrease after the clipping, various peak re-growth can also occurred, that in the clip level the peak signal is enlarged. With no spectrum extension the PAPR is minimized by the mechanism of iterative clipping and the filtering. Therefore, the more time is taken by the iterative signal that will maximize the computational complications of the OFDM transmitter. Before clipping with no operating interpolation the out-of-band occurs. After the interpolation the signal must be clipped to evade the out-of-band. Therefore, the considerable peak re-growth occurs. However the iterative clipping and the frequency domain filtering is utilized to evade the peak re-growth.

a. Upper Threshold
b. Lower Threshold

c. Convex Optimization Algorithm

The convex optimization technique applies the convex analysis based mathematics for optimizing the solution. In convex optimization, following terms and mathematics is used.

Let's a set C is a convex set if the line segment among any two points in C i.e. if for any $x_1, x_2 \in C$ $and\ any\ \alpha\ with$ $0 \leq \alpha \leq 1$, we have $\alpha x_1 + (1-\alpha)x_2 \in C$. For example, the $C_1\ and\ C_2$ can be expressed as follows:

$$C_1 = \{x|\ \|x\|_2^2 \leq 1, x \in R^2\}, C_2 = \{x|\ \|x\|_2^2 \geq 1, x \in R^2\} \dots (1.6)$$

The figure 1 shows that the C_1 is a convex set and C_2 is a non convex set. The C_2 comprised of boundary and outer part of the circle and the line segment between some point did not related to the C_2. A function $f: R^n \longrightarrow R$ is a convex if $domf$ is a convex set and if for all$x, y \in domf, and\ \alpha\ with\ 0 \leq \alpha \leq 1, we\ have\ f(\alpha x + (1-\alpha)y) \leq \alpha f(x) + (1-\alpha)f(y)$. geometrically; this inequality defines the line segment between $(x; f(x))and\ (y; f(y)$. For an optimization problem,

$$\min \begin{matrix} f_0(x) \\ s.t. f_i(x) \leq 0, i = 1, \dots, I \\ h_j(x) = 0, j = 1, \dots, J \end{matrix} \dots\dots (1.7)$$

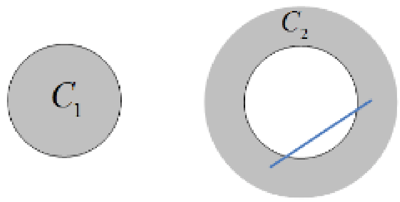

Fig. 1 Example of convex and non-convex set

1. First step is to generate the information in the form of signals. These signals are used for transmission and further processing.
2. After generating the signals, next step is to apply N point IFFT technique. IFFT is Inverse Fourier Transformation.
3. Next step is to apply clipping to the signals in two different steps as follows:
   a. Upper threshold clipping: In this the upper part of the signal is clipped by using the threshold value.
   b. Lower threshold clipping: In this the lower part of the signal is clipped on the basis of the threshold value.
4. The N-point FFT is applied to the clipped signals.
5. In last, the convex optimization is applied to the transformed signals.

Following is the methodology of proposed work.

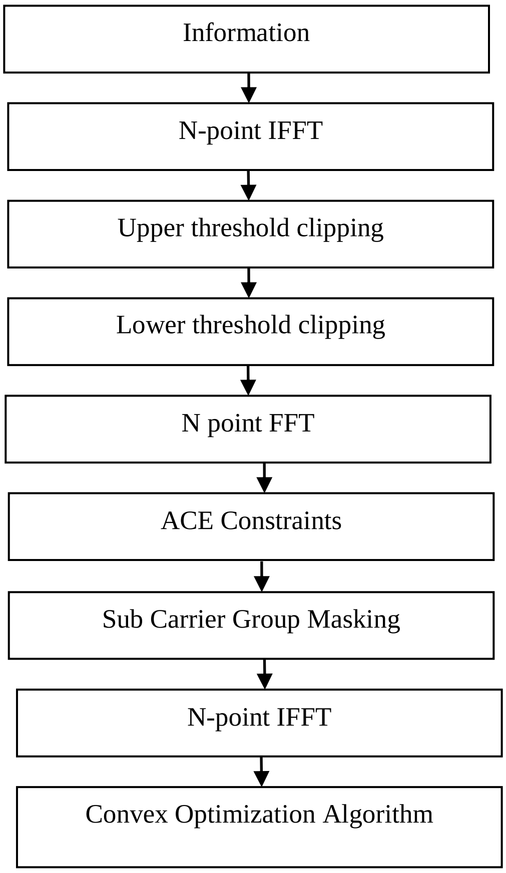

Fig. 2 Framework of proposed work

IV. RESULTS

The Matlab is used for modelling a system to analyze the existing and proposed scheme for PAPR and BER reduction. Fig. 3 shows the PAPR plots of the proposed scheme. It can be seen that the peak insertion technique gives the highest PAPR reduction as compared to the existing scheme that can be concluded form the results given in table.

The BER reduction performance of existing and proposed scheme is also analyzed for different values of U where value of U is taken as per given above for PAPR performance analysis. The assumptions has been taken that there is proper synchronization between transmitter and receiver.

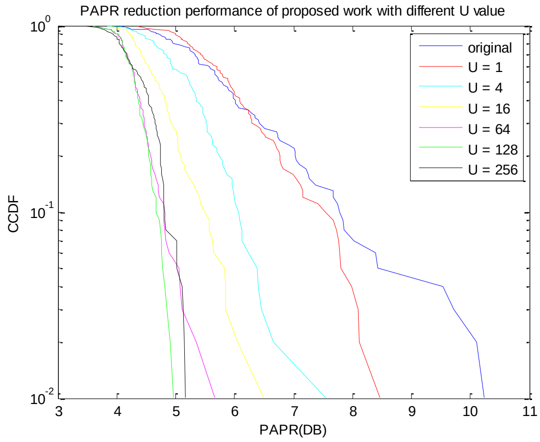

Fig. 3 PAPR reduction performance of Proposed Scheme for different values of U

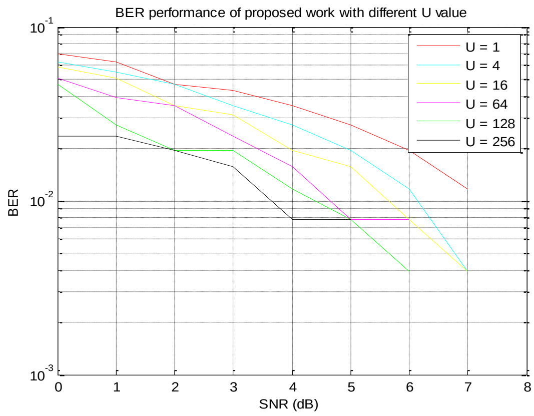

Fig. 4 BER reduction performance of Proposed Scheme for different values of U

This figure 4 gives the result of proposed scheme for total 256 sub carrier. The results are evaluated in the terms of BER. The x axis in the graph depicts the SNR and y axis calibrates the data in the form of BER. The BER of U=1 is the highest and for U=256 is the lower BER.

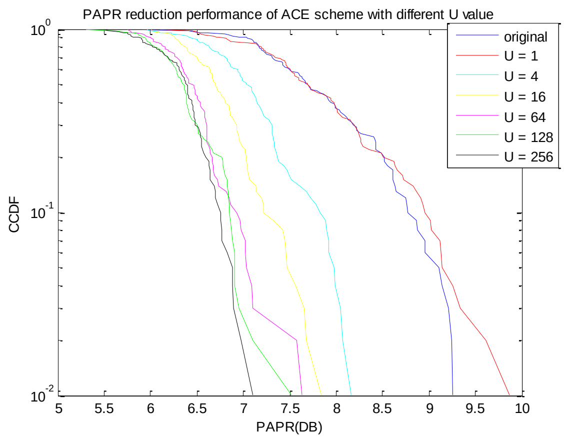

Fig. 5 PAPR of ACE Scheme for different values of U

The graph in figure 5 shows the PAPR of ACE scheme. The evaluation is done by using various values of U i.e. from 1 to 256. The x axis in the graph shows the values for PAPR and it ranges from 5 dB to 10 dB. Whereas the y axis states the values for CCDF. It has been observed that the PAPR of u=1 is the higher PAPR and the lowest PAPR is observed for u=256.

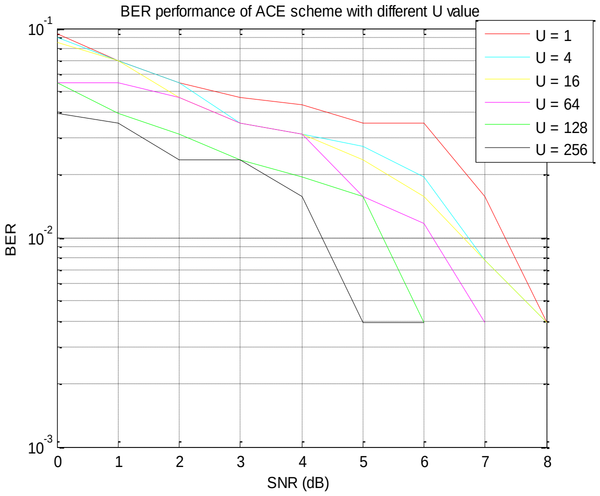

Fig.6 BER of ACE Scheme for different values of U

The graph in figure 6 shows the performance analysis of BER for ACE scheme. The BER for various values for u is evaluated and it is observed that the BER for u=256 is the lowest one.

Table. 1: Comparison table of PAPR reduction performance of the Existing with that of Proposed Scheme for different values of U:

PAPR	Existing	Proposed
U=1	9.8708	8.4659
U=4	8.1574	7.5402
U=16	7.8379	6.4885
U=64	7.6301	5.6637
U=128	7.5138	4.9569
U=256	7.1050	5.1579

This is the table for comparison results of existing and proposed scheme for different values of U where U is a real number whose value is taken according to 2^n.

V. CONCLUSION

For multicarrier communication system, OFDM is considered as the major technique due to its various properties such as high data packet transmission rate, standard choice of communication channels etc. After having so much characteristics or properties, the OFDM also suffers from various issues such as high PAPR, BER etc. After having a survey to the traditional OFDM researches, it has been observed that the high PAPR is the most complicated issue in OFDM and it needs to resolve in order to enhance the performance of OFDM system. A large number of techniques has been developed but lacks at some points to achieve the benchmark of efficient performance. Out of these available techniques, it has been perceived that the clipping is a quite efficient mechanism that is an aid to reduce the PAPR of the system. Consequently, this study develops a novel approach for reducing the PAPR and BER of the OFDM system introducing the concept of threshold based upper and lower clipping of the signals. Along with this the N-point FFT\IFFT modulation is also applied to modulate the signals. The convex optimization technique is implemented to optimize the modulated signals at last so that a reduction in PAPR and BER can be achieved.

The present work of PAPR and BER reduction in OFDM system can be modified in future by introducing the Swarm based optimization technique

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