March-April 2020
ISSN: 0193-4120 Page No. 15238 - 15244

Optimization of PAPR for OFDM Systems Using Clipping and Tone Reservation

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Abstract:
OFDM System has a significant disadvantage that is large PAPR leading to lower power proficiency and non-linear distortion at the transmit power amplifier. There are various techniques to reduce PAPR. Clipping using Tone Reservation (TR) with SDR is incorporated in this paper. Tone reservation (TR) is one of the alluring techniques to reduce peak-to-average power ratio (PAPR) in OFDM. It brings about computational complexity that increments exponentially with the number of subcarriers. Also, clipping fundamentally cuts off the random peaks that show up in an OFDM System and reduces the PAPR. The simulation results show that clipping and tone reservation is a proficient method to reduce PAPR with SDR implementation.

Keywords*:OFDM, PAPR, Clipping, Tone Reservation.*

I. INTRODUCTION

with the latest technologies, the area of wireless communication system has experienced a huge change in the last decade. The advancement of universally known standards in wireless and mobile network has additionally utilized the dynamic communication system. Orthogonal Frequency Division Multiplexing is a multi-carrier modulation method that bolsters transmission of the data packet utilizing multiple sub-carriers for better use of the channel capacity. The theory states that the spacing of the signal carriers are equal to the inverse of the symbol period henceforth such carrier spacing will have the entire cycles of the symbol period that will result in negative interference. Figure 1 shows the conventional spectrum produced by the Orthogonal Frequency Division Multiplexing for n number of signal carrier. OFDM is presently embraced in multiple wireless communication system that requests high data rate. The ability of OFDM is further improved by including the multiple number of antennas over the wireless connections that is essential to upgrade the spectral efficiency as well as superior reliability factor of a connection in upcoming generation of mobile networks and communication system.

MIMO OFDM system permits better capacity, adaptability, and efficiency with amplified rate of data transmission with minimal bit error rate. Therefore, multiple antennas are used for cancelling interference just as to understand the diversity and gain in array utilizing coherent combination. Apart from its use in radio and video broadcasting, OFDM is right now utilized in 4G systems, LTE (Long-Termed Evolution) network, and forthcoming 5G network.

March-April 2020
ISSN: 0193-4120 Page No. 15238 - 15244

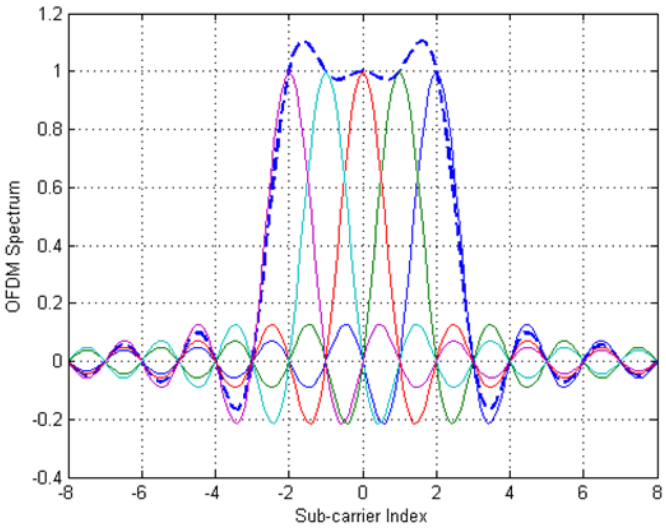

Figure 1: linearity feature of the signal generated by the OFDM

Thus making OFDM alluring in the design of modern communication system for efficient management of rare radio frequency bandwidths.

II. RELATED STUDY

A. PEAK-TO-AVERAGE POWER RATIO (PAPR)

High peak-to-average power ratio (PAPR) issue restricts its wide reception in some communication devices. PAPR causes performance degradation. High Power Amplifier's non-linearity gives in band distortion with high BER, leading to inter channel interference. On account of high PAPR, the OFDM signal will be clipped when it passes through a non-linear high power amplifier (HPA) and therefore, the performance will be degraded and in-band distortion and out-of-band distortion will happen. Thus, the OFDM transmitters require expensive linear HPA with a wide dynamic range .Based upon the significant performance degradation of the system, there are various number of PAPR reduction techniques for OFDM systems such as clipping, coding, non-linear companding, tone reservation and tone injection, selective mapping (SLM) and partial transmit sequence (PTS)

PAPR is defined as the ratio of the maximum power to the average power and can be written in general as:

$$PAPR(dB) = 10log\left(\frac{max[X(t)X^*(t)]}{E[X(t)X^*(t)]}\right) \quad (1)$$

Where X (t) denotes an OFDM signals after IFFT, and

E [.] denotes expectation.

B. COMPLEMENTARY CUMMULATIVE DISTRIBUTION FUNCTION (CCDF)

CCDF is typically used to determine the performance of the PAPR reduction technique. The CCDF is the probability that the PAPR of an OFDM signal surpasses a threshold level $PAPR_0$ and it can be written as:

$$CCDF = P(PAPR > PAPR_0) = 1 - (1 - e^{-PAPR_0})^N \quad (2)$$

Where $PAPR_0$ is the clipping limit. This equation is called as the probability that the PAPR of a symbol block exceeds some clipping limit $PAPR_0$.

C. DISCRETE COSINE TRANSFORM (DCT)

A discrete cosine transform (DCT) is defined as a sequence of data points which is the sum of cosine functions at various Frequencies. It converts a signal from the spatial domain to the frequency domain. They use cosine rather than sine functions because it is critical for compression. DCT utilizes

only real numbers. The plan to utilize the DCT transform is to reduce the autocorrelation of the input sequence to reduce the peak to average power problem and it requires no side information to be transmitted to the receiver. The 1D discrete cosine transform (1D DCT) B[k] of a sequence b[n] of length N is defined as:

$$B[k] = b[k]\sum_{n=0}^{N-1} b[n]\cos[\frac{\pi(2n+1)}{2N}]$$

March-April 2020
ISSN: 0193-4120 Page No. 15238 - 15244

(3)

For k =0,1,….N-1 and n=0,1,….N-1

Where b[k] is defined as:

$$b[k] = \begin{cases} \sqrt{\frac{1}{N}} & for\ k = 0 \\ \sqrt{\frac{2}{N}} & for\ k = 1,2,\ldots . N-1 \end{cases}$$

(4)

The basis sequences of the 1D DCT are real, discrete-time sinusoids defined by:

$$S_N[n,k] = \cos\frac{\pi(2n+1)k}{2N}$$

(5)

N real sequences of DCT

$$S_N[n,0], S_N[n,1], \ldots \ldots \ldots S_N[n,N-1]$$

(6)

The above equation is expressed in matrix

$$B = S_N b$$

(7)

This paper presents a novel approach based on clipping and tone reservation to overcome the computational complexity of the PAPR reduction problem.

III. PROPOSED PROBLEM

A. CLIPPING

Of all the PAPR reduction techniques, clipping is the most simplest and least computational to implement. In clipping, the signals high parts which are outside the permitted threshold region are clipped. However, this technique is simple. It has a few disadvantages:

•Clipping causes in-band distortion which could impact the Bit Error Rate.

•Out-of-band radiation caused by clipping prompts adjacent channel interference.

By repeatedly clipping and filtering operation, the peak re growth caused by filtering can be reduced, while at the same time improving the PAPR performance.

y[m] denotes the pass band modulated signal with carrier frequency f. $y_b^a[m]$ is the clipped pass band modulated signal. The clipped signal is expressed as:

$$y_b^a[m] = \begin{cases} -R & y^a[m] \le -R \\ y^a[m] & |y^a[m]| < R \\ R & y^a[m] \ge R \end{cases}$$

(8)

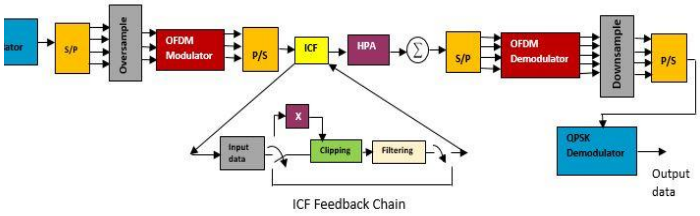

Figure 2: Block Diagram for clipping

B. TONE RESERVATION

Tone reservation (TR) is one of the various strategies for decreasing the PAPR. TR relies on reserving subcarriers (referred to as reserved tones) out of the total of subcarriers for PAPR reduction purposes. Two parameters that is the weight factor and the clipping proportion have significant sway on the PAPR decrease. TR method uses non data carrying subcarriers added to the main signal, helping to reduce the overall PAPR of the OFDM symbol.

March-April 2020
ISSN: 0193-4120 Page No. 15238 - 15244

C. SOFTWARE DESIGNED RADIO (SDR)

SDR alludes to the innovation wherein programming modules running on a conventional equipment stage comprising of DSPs and general purpose microprocessors are utilized to actualize radio functions, for example, processing of transmitted signal (modulation) at transmitter and tuning/identification of received radio signal (demodulation) at receiver.

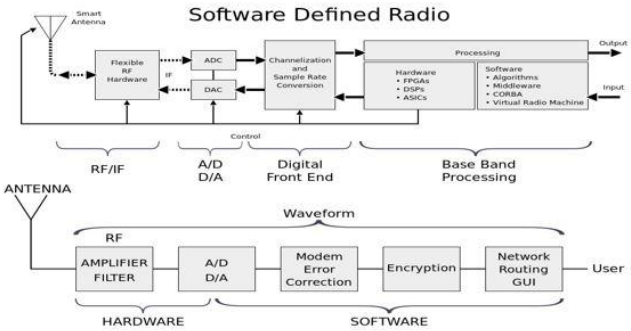

Figure 3: Block Diagram for SDR

IV. RESULT

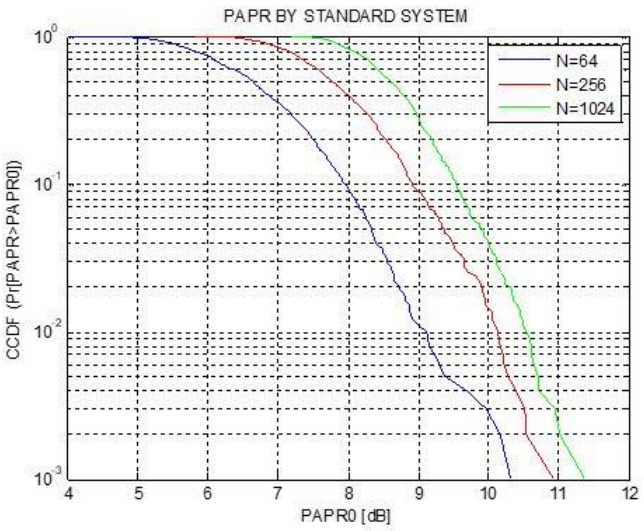

Figure 4: PAPR of basic OFDM system with no techniques applied

Figure 4, shows PAPR of a signal in normal OFDM system without using any reduction methods. By using reduction methods PAPR is reduced from 11 dB to lower values.

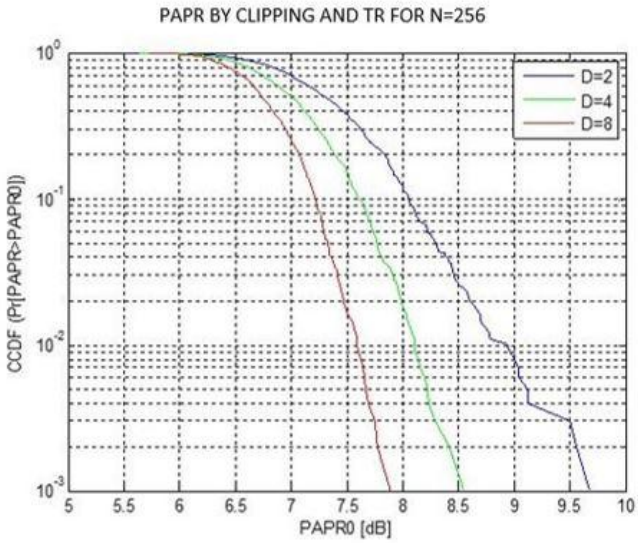

Figure 5: PAPR of conventional clipping and tone reservation system

Figure 5, represents the PAPR reduction performance using
Clipping and tone reservation method. As D increases, the PAPR of the signal comes down.

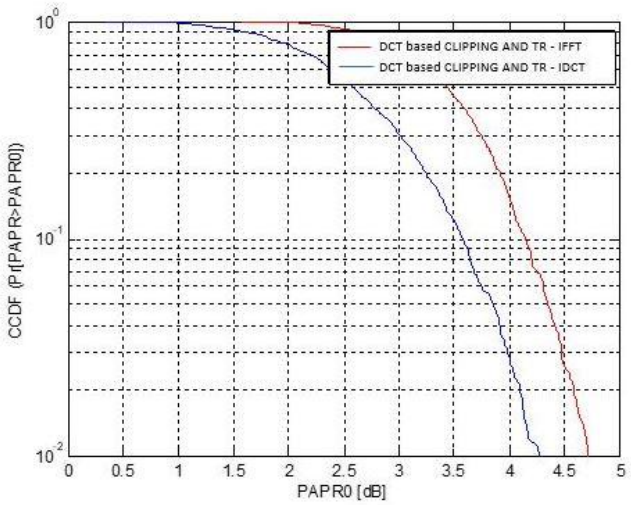

Figure 6: PAPR performance of OFDM signals when N=4 and K=256 using IFFT and IDCT.

Figure 6, shows reduction in PAPR that is achieved by using DCT clipping and tone reservation**.**

March-April 2020
ISSN: 0193-4120 Page No. 15238 - 15244

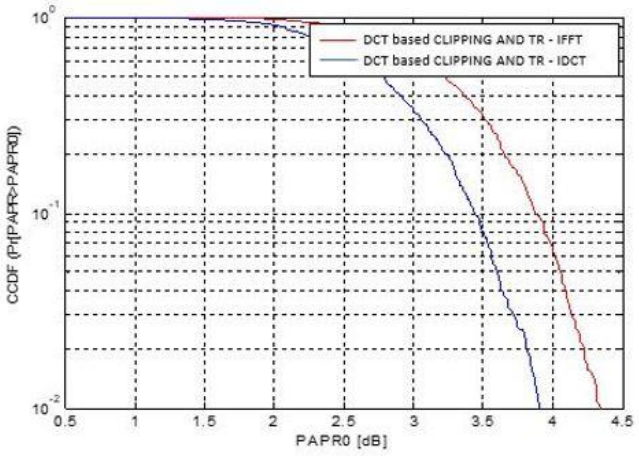

Figure 7: PAPR performance of OFDM signals when N=4 and K=512 using IFFT and IDCT.

Figure 7, shows when the DCT based modified clipping and tone reservation method is used the PAPR value is reduced to 4.5 dB. Whereas for the conventional clipping and tone reservation it is up to 9.6 dB.

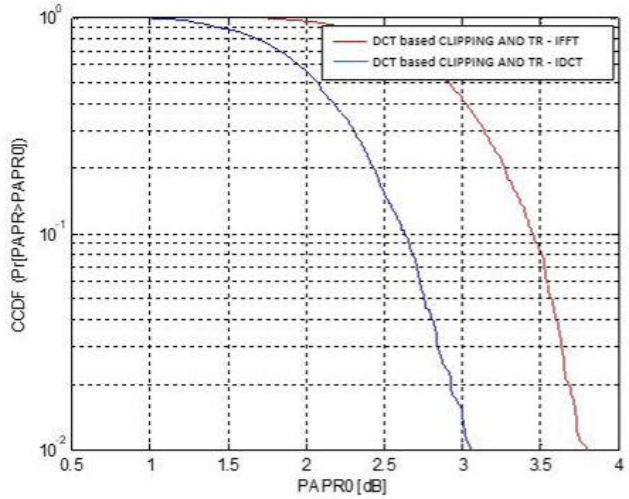

Figure 8: PAPR performance of OFDM signals using IDCT

Figure 8, shows that the PAPR value is reduced at a higher level for the IDCT when compared to the IFFT (i.e.) during IDCT method the PAPR decreased to 3.9 dB.

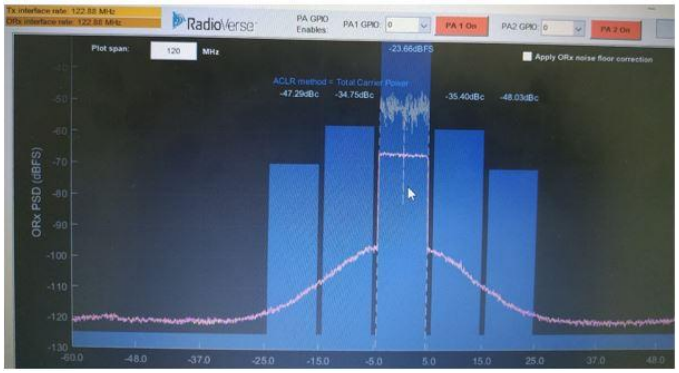

Figure 9: PAPR reduction using SDR

V. CONCLUSION

In this paper, simulation results for OFDM systems using clipping and tone reservation with SDR implementation is shown. These two techniques are one of the best methods. Both these techniques reduces the peak-to-average-power ratio (PAPR) to increase sampling number, data rates and better spectral efficiency. Also the advantages and disadvantages of two algorithms i.e. Clipping and tone reservation were summed up and the occasions of their respective adaptation were pointed out. Hence the simulation results show that PAPR in this paper is reduced up to 4.5 to 3.9 dB.

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