An Improved Clipping And Filtering Methods With Discrete Cosine Transform (DCT) For Peak-To-Average Power Ratio (PAPR) Reduction

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***Abstract*—Orthogonal Frequency Division Multiplexing (OFDM) acts as a modulation scheme for wideband digital communication and is nowadays applied in wireless networks, 4G mobile communications and audio broadcasting. This system has a lot of advantages over single carrier modulation systems. High transmission bit rate, high spectral efficiency and robustness to frequency fading channels has been the great benefit for the application of OFDM. However, there are some drawbacks in OFDM systems which are high Peak-to-Average Power Ratio (PAPR). High PAPR reduces the performance of signal transmission. The mentioned drawback is the most important reason for this paper being established to look into the problem and apply some methods or techniques to reduce the PAPR. High PAPR will reduce the performance of OFDM in term of signal transmission. This project presents the improved method of Clipping and Filtering with DCT to reduce PAPR of OFDM system by comparing the modulation scheme, number of subcarriers and Clipping Ratio (CR). The DCT/IDCT replace the FFT/IFFT in the filtering method and this will creates a better performance of PAPR reduction.**

Keywords—OFDM, PAPR, DCT, IDCT, CR

I.INTRODUCTION

Orthogonal Frequency Division Multiplexing (OFDM) provides many advantages for multipath transmission over time dispersive channels, especially at high data rates. OFDM is applied in wide variety of wireless digital communication over the past several years. It is also adapted to the wireless LAN standards as IEEE 802.11a/g. This is due to OFDM can overcome the problem of Intersymbol Interference (ISI), delay spread of signal and increase the spectral efficiency of system. [1]. In addition, in [2], Gu at al. commented that OFDM has larger system capacity than traditional single carriers system, a strong ability to overcome the frequency selective fading and high frequency spectral efficiency. High peak-to-average power ratio (PAPR) is one of the major disadvantages of OFDM signal, which has been a restriction to the development of OFDM.

There are several proposed schemes for reducing PAPR and it can be majorly divided into two categories

a) Distortion based Techniques such as Clipping and Filtering, µ-law companding, exponential companding (EC) function and trapezium distribution based companding (TDBC).

b) Non-distortion Techniques such as coding, partial transmit sequence (PTS) and selective mapping (SLM) and Multi-Point Square Mapping Combined with PTS [3].

II.DESCRIPTION OF PAPR IN OFDM SYSTEM

Here we discuss one of the major drawbacks of the OFDM system. Drawback is high PAPR (Peak-to-Average Power ratio). PAPR means randomly sinusoidal leads occurred during transmission of the OFDM signal. So as per the introduction of PAPR we can judge that to reduce the PAPR is most important point in the OFDM system. Because of when we are talking about the high speed data communication in real life like video calling, high speed internet access, and also main point is that high speed data access up to 2mbps while moving on the vehicle at 100km/h, digital video broadcasting (DVB), Microwave terrestrial television, Digital audio broadcasting (DAB), 4G system, hyper LAN. So this most type of communication systems required high data rate. But problem occurs like PAPR in OFDM system prevent these types of facilities in the real life. Thus, it is important to reduce PAPR.

PAPR is defined as the maximum power occurring in the OFDM transmission to the average power of the OFDM transmission. Mathematical representation has been given below.

$$PAPR = \frac{P_{peak}}{P_{average}}$$

where P_{peak} = Peak power of the OFDM system, $P_{average}$ = Average power of the OFDM system.

A basic OFDM system has an input data symbols are supplied into a channel encoder that data are mapped onto BPSK/QPSK/QAM constellation. The data symbols are converted from serial to parallel and using Inverse Fast Fourier Transform (IFFT) to achieve the time domain OFDM symbols. [4]

For an OFDM system with N subcarriers, OFDM signal in baseband notation in discrete form can be expressed as:

$$X_n = \mathrm{IFFT}\{X_k\}$$

$$X(t) = \frac{1}{\sqrt{N}} \sum_{k=1}^{N-1} X_k e^{j2\pi k\Delta ft}$$

Where X_k is transmitted symbol on the K_{th} subcarrier and N is number of subcarriers

III. THE RELATED WORK FOR IMPROVED METHOD OF CLIPPING AND FILTERING WITH DCT

The improved Clipping and Filtering method with DCT actually a combined method of the two respective methods.

To limit out-of-band radiation and PAPR, Jean Armstrong proposed iterative clipping and filtering scheme [5]. In the clipping technique hard limiting is applied to the amplitude of the complex values of the IFFT output. The filtering technique is designed to alleviate out-of-band distortion but cannot correct in-band distortion. The filtering operation will lead to peak power regrowth).

Figure 3.1 show the flow of Clipping and Filtering method

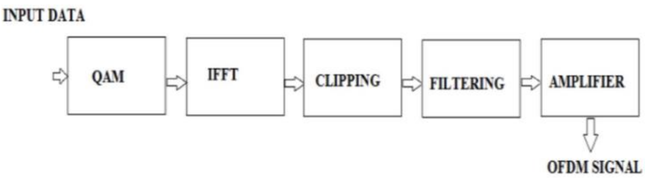

Figure 3. 1: Clipping and Filtering in OFDM [5]

The Discrete Cosine Transform is a Fourier-like transform, which was first proposed by Ahmed et al. (1974) [6]. To reduce the PAPR in an OFDM signal, DCT is applied to reduce the autocorrelation of the input sequence before the IFFT operation. The one-dimensional DCT with length N is expressed as:

$$X[k] = \propto (t) \sum_{n=0}^{N-1} x\ (n) \cos\left\{\frac{(2n+1)\pi k}{2N}\right\} \quad 0 \le k \le N-1$$

At the receiver inverse discrete cosine transform is calculated. The IDCT is expressed as [6]:

$$x[n] = \propto (t) \sum_{k=0}^{N-1} X\ (k) \cos\left\{\frac{(2n+1)\pi k}{2N}\right\} \quad 0 \le n \le N-1$$

Sroy Abouty et al. proposed a PAPR method reduction method, which is combination of DCT with Clipping and Filtering technique. In this research, two schemes have been proposed which are DCT is used after Fast Fourier Transform/ Inverse Fast Fourier Transform and DCT is used after Clipping and Filtering [7].

IV. THE PROPOSED IMPROVED METHOD

The Clipping and Filtering method proposed by Sroy Abouty et al. involves number of iteration of Clipping and filtering. The number of iterations gives the results of more appropriate PAPR reduction with the increasing numbers of Clipping and Filtering repetitively. However, in the method proposed in this paper, number of iteration is not much taken inconsideration in this project. Therefore, one number of iteration of Clipping and Filtering is used and followed by DCT/IDCT. Besides that, the proposed method by Sroy Abouty et al. involves only QPSK.

A. Clipping and Filtering technique

The data obtained from the QPSK and QAM Mapping is being clipped based on the Clipping Ratio (CR) which is set initially at the beginning of the simulation. The clipping process begins with the comparison of the absolute value of x (Modulated data) which are greater than the product of the value of clipping ratio (CR) with the average power. The value 'x' which meets the condition, is selected from the data. Figure 4.1 shows how Clipping Ratio is applied in MATLAB simulation.

```
%Improved CF with DCT
% Clipping
x_tmp = x(Signal_Power>(CR*Mean_Power));
x_tmp = sqrt(CR*Mean_Power)*x_tmp./abs(x_tmp);
x(Signal_Power>(CR*Mean_Power)) = x_tmp;
```

Figure 4. 1: Clipping Ratio

The next data is obtained with the value 'x' in the form of data set obtained above through this equation:

$$x_m = \frac{x\sqrt{CR(Mean\ Power)}}{|x|}$$

B. DCT/IDCT replacing the FFT/IFFT

During the filtering process, Discrete Cosine Transform and Inverse Discrete Cosine Transform will replace Fast Fourier Transform and Inverse Fast Fourier Transform in playing the role of filtering process. The reason behind this replacing method is the discrete value produced after undergone in DCT/IDCT is lower than FFT/IFFT. Figure 4.2 shows the flow of the improved Clipping and Filtering technique with DCT

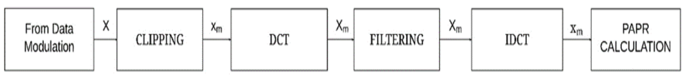

Figure 4. 2: Improved Clipping and Filtering Technique

C. Procedure for completion of project

Figure 4.3 shows the flowchart of design implementation of improved Clipping and Filtering with DCT.

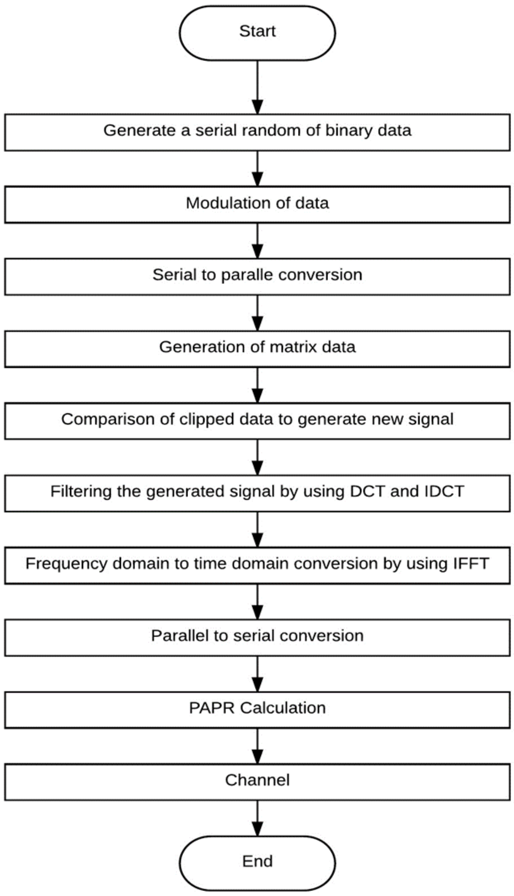

Figure 4. 3: Flowchart of design implementation

Table 4.1 Parameters for QPSK, 16QAM and 64QAM modulations

No.	Parameter	Value
1	Total number of subcarriers	64,128, 256,512, 1024
2	Modulation Scheme	QPSK, 16-QAM, 64-QAM
3	Clipping Ratio	4,6,8
4	Number of symbol	10000
5	Number of iteration	1

V. RESULTS AND DISCUSSIONS

A. Modulation scheme

Performances of OFDM system are mostly referred to complementary cumulative distribution function of the PAPR value. In this project, 3 parameters is being compared which are type of modulation scheme used, number of subcarriers and number of clipping ratio.The comparison of PAPR value reduction between the QPSK, 16-QAM and 64-QAM with number of subcarriers = 64 and Clipping Ratio of 4 is shown in the next 3 graphs.

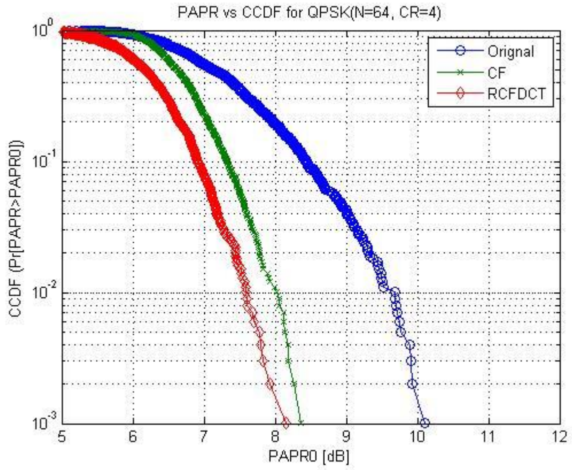

Figure 5. 1: Graph of CCDF with QPSK

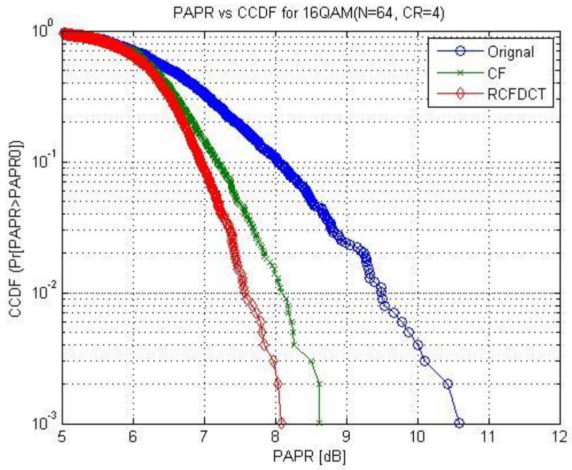

Figure 5. 2: Graph of CCDF with 16-QAM

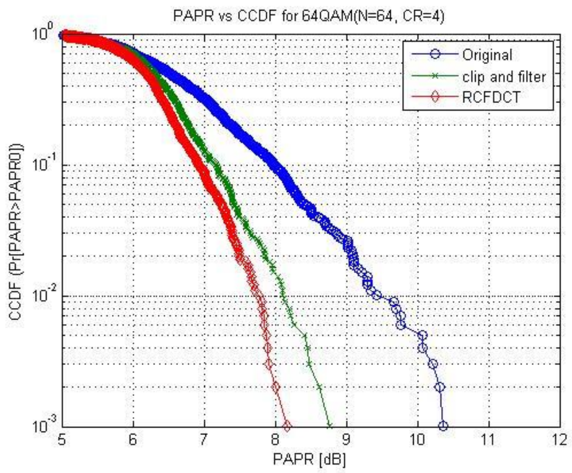

Figure 5. 3: Graph of CCDF with 64-QAM

B. Number of Subcarriers

The comparison of PAPR value reduction between different numbers of subcarriers for QPSK modulation scheme with Clipping Ratio of 4 is shown in the next five graphs.

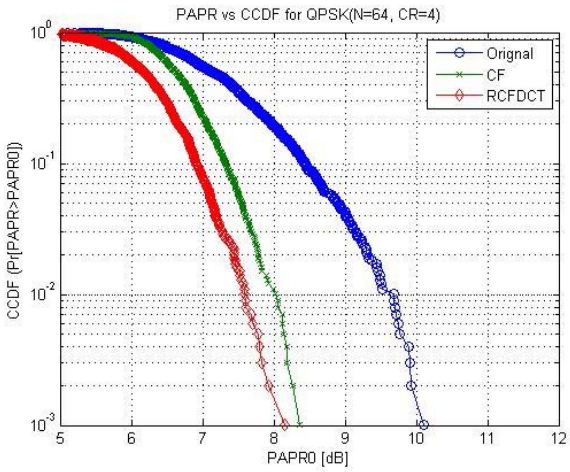

Figure 5. 4: Graph of CCDF with QPSK N=64

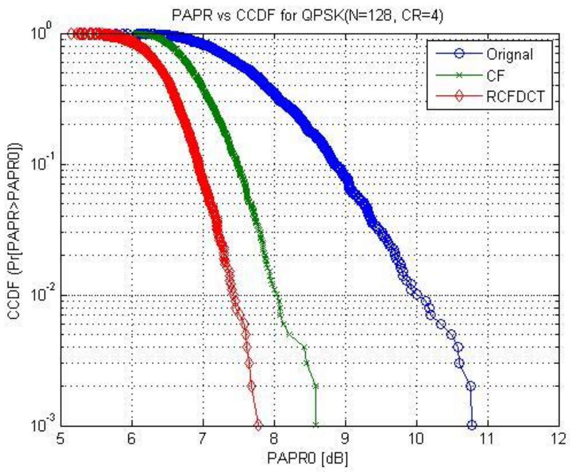

Figure 5. 5: Graph of CCDF with QPSK N=128

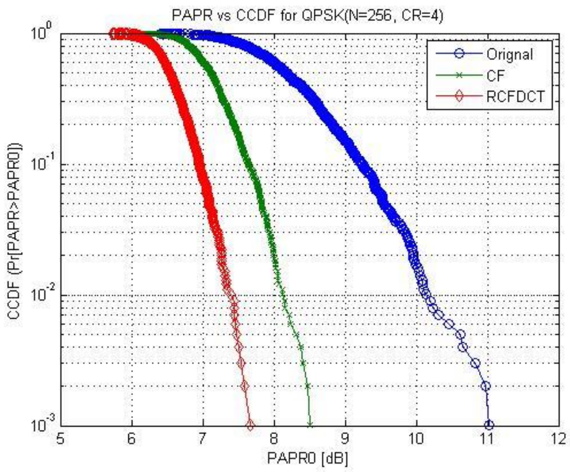

Figure 5. 6: Graph of CCDF with QPSK N=256

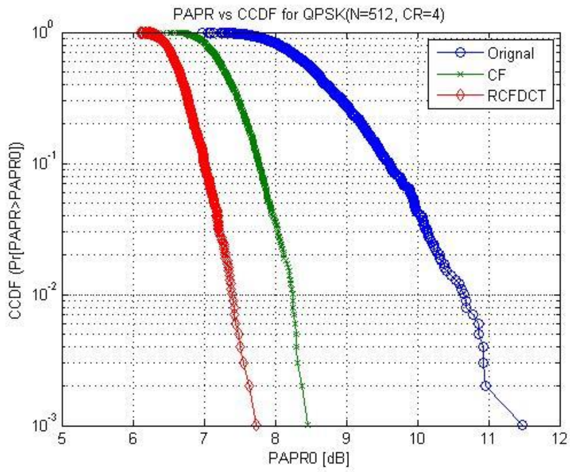

Figure 5. 7: Graph of CCDF with QPSK N=256

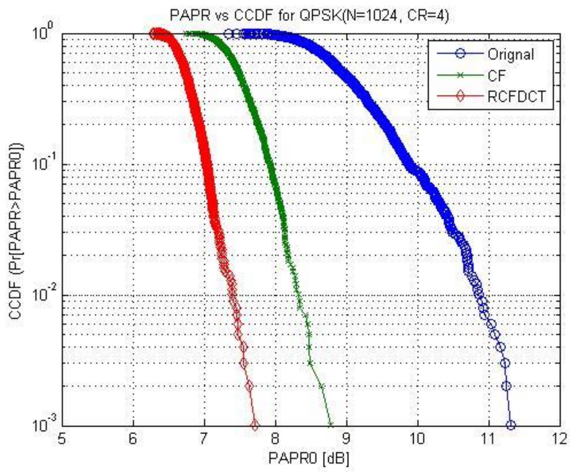

Figure 5. 8: Graph of CCDF with QPSK N=1024

C. Clipping ratio

The comparison of PAPR value reduction between Clipping Ratio for 64-QAM modulation scheme with number of subcarriers = 64 is shown in the next three graphs.

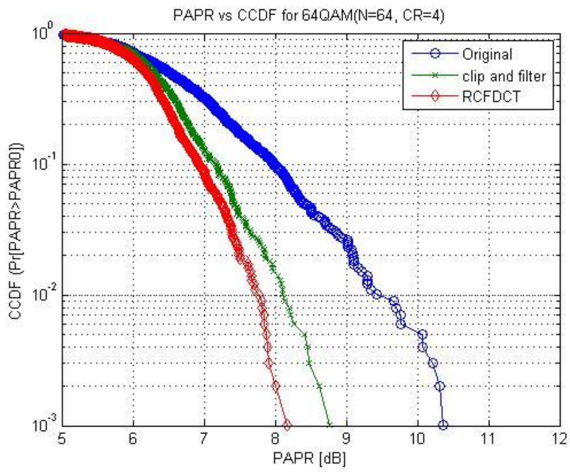

Figure 5. 9: Graph of CCDF with QPSK CR=4

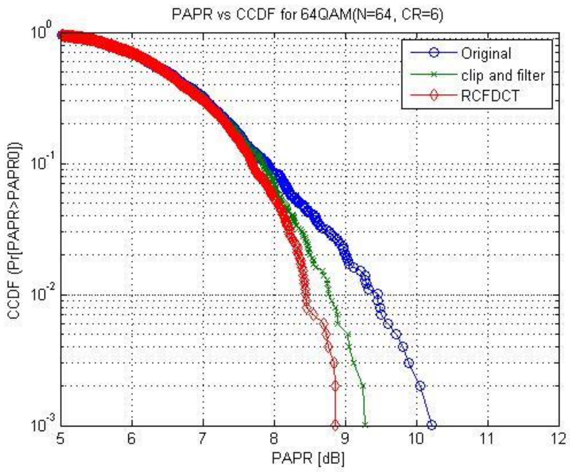

Figure 5. 10: Graph of CCDF with QPSK CR=6

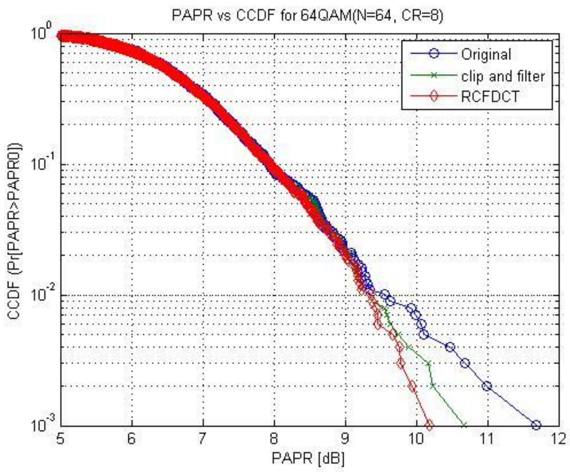

Figure 5. 11: Graph of CCDF with QPSK CR=8

VI. CONCLUSION

Orthogonal Frequency Division Multiplexing (OFDM) is one of the common modulation scheme used in wideband digital communication and high data rate wireless communications systems. It is important to reduce the Peak to Average Power Ratio (PAPR). Thus, improved Clipping and Filtering method with DCT is implemented to reduce PAPR based on parameters shown. 64-QAM shows the highest improvement of PAPR reduction, the higher the number of subcarriers, the greater the value of PAPR reduction and the greater the Clipping Ratio, the lesser the PAPR value. From the results, we can deduce that the proposed improved Clipping and Filtering technique can reduce PAPR with significant value compared to original technique.

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