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Performance Comparison of Companding Techniques and New D-Cast Method for Reduction of PAPR in OFDM

Harpreet Bedi, Isha Puri, R.K. Sharma and Shekhar Verma*

ABSTRACT

This paper proposes a new D-cast method to reduce the Peak to Average Power Ratio(PAPR) by minimizing the overall bit error rate as well as the out-of-band interference(OBI) in the Orthogonal Frequency Division Multiplexed Signals. One of the main drawbacks of OFDM signals is that they suffer from high PAPR. Although there are multiple PAPR reduction techniques but comparisons have shown that the Companding technique and D-cast method are more effective in the reduction of PAPR to improve the signal quality in addition to being less complex. This paper includes the comparison between various PAPR reduction methods and shows how the proposed method turns out to be the best one.

Index: OFDM, BER, Companding PAPR, D-CAST.

1. INTRODUCTION

Orthogonal Frequency Division Multiplexing is a key technology in communication. OFDM is a technique which uses multicarrier modulation with several carriers within a large bandwidth to transmit information from source to destination. OFDM is used in several celluar and wireless LAN standards such as 4G wireless system, digital audio and video broadcasting standards and WiMAX because it is a broad band technology which enables high data rate. When we take a signal with large bandwidth B where delay spread spectrum (Td) is greater than symbol time (T) then it leads to Inter Symbol Interference (ISI). ISI leads to a degradation of performance of wireless communication system. When this large bandwidth B is subdivided into N subcarriers and sub bands then T>>Td which eliminates the interference. the system with multiple sub bands and sub carriers is termed as a multi carrier modulation system. This is one of the important advantage of OFDM eliminating Interference.ofdm provides high data rate and it will not effect by inter symbol interference. In spite of having more advantages, OFDM system also has some drawbacks one of the Drawback is high PAPR. To reduce high PAPR several reduction techniques are introduced such as clipping, and filtering, block coding, selective mapping etc. The simplest solution of all these techniques is when signal amplitude exceeds a desired or expected threshold then just clip the signal. Clipping is associated with highly nonlinear process. When we clip the signal it produces a significant OBI (out of band interference). This paper proposes a better approach and evaluates a new d-cast method which is linear transform. This technique results an minimum amount of bit error rate and effectively minimized OBI while reducing PAPR .This paper is arranged in the following way. Next section gives BER of OFDM. Section 3 presents PAPR of OFDM. Section 4 gives PAPR reduction techniques that is companding algorithm and d-cast technique its theoretical analysis, performance simulations and the last section gives the conclusion.

2. BIT ERROR RATE

As there are so many metrics to characterize the performance of communication system but one of the most convenient and most informative metric is the Bit Error Rate (BER). BER is a metric which is employed to

* Department of ECE, Lovely Professional University, Phagwara
Correspondence author: Shekhar Verma

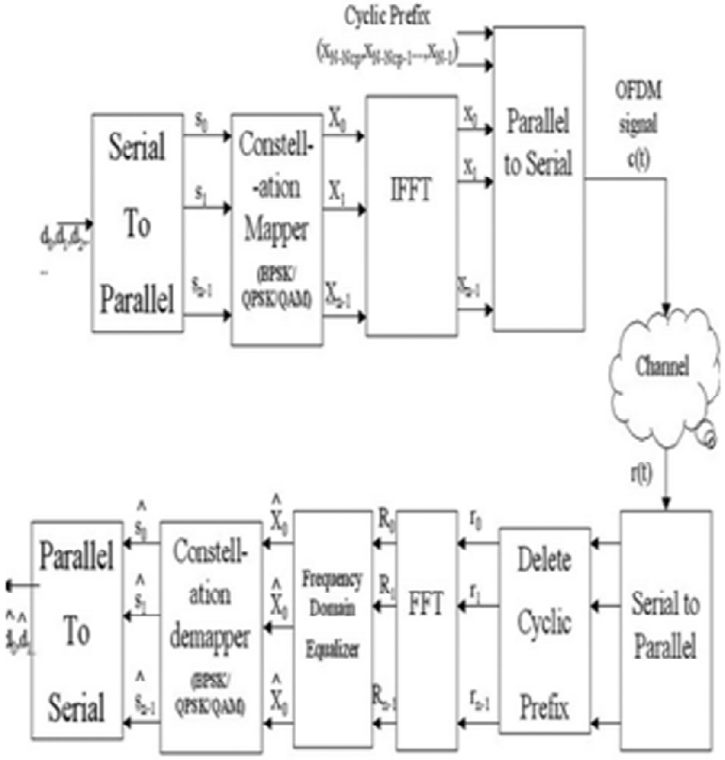

Figure 1: Block diagram of OFDM systems

characterize the performance of OFDM system. In OFDM as we transmit the bits of information from transmitter to receiver but sometimes the transmitted bits are not received correctly by the receiver frequently there are errors during the reception of bits. For example let us consider a stream of information which is also known as bit stream transmitted as 1 0 1 0 1 1 0 0 0 1 at the receiver the transmitted bits are decoded as 1 0 0 0 1 1 0 0 0. Here two transmitted has changed so there are bits errors that occurred during the transmission is the average rate of bit errors for a communication system. We consider the Gaussian Noise which has Gaussian probability distribution function.

$$\text{Bit error rate} = BER = \frac{1}{2} erfc\left(\sqrt{E_b / N_0}\right).$$

Where Noise is Guassian so mean is zero and variance is.

3. PAPR IN OFDM

PAPR stands for peak to average power ratio. In OFDM system, we do not directly transmit the data symbols directly, instead we transmit the data symbols with N sub carriers. Let us consider the data symbol in OFDM as X(0), X(1), X(2), X(3)… X(N-1). Before transmitting the data symbols we perform an IFFT operation over the data symbols. Let the transmitted samples are x(0), x(1), x(2), x(3) … x(N-1) which are IFFT samples of the data symbols X(0), X(1), X(2), X(3) …. X(N-1). Hence the samples are given as

$$x(t) = 0$$

Where T is the OFDM symbol time duration. The symbols that we have used to transmit are assumed to be individual and are equally distributed. As per the central limit theorem if N sub carriers are large, then real and imaginary parts are equally distributed with zero mean and variance and amplitude of the signal have Rayleigh distribution. We define PAPR as the ratio of the maximum power of the signal to the average signals power. Practical devices like amplifiers have limited linear amplification range and the swing of the peak power can be very high compared to the mean so amplification range i.e amplitude must be limited.

Mathematically PAPR in dB is defined a

$$PAPR = 10\log10\ (DB)$$

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We characterize the PAPR of a system using CCDF.CCDF stands for complementary cumulative distributed functon. CCDF is the probability where PAPR exceeds the desired or threshold which is given as

$$CCDF = probability\ (PAPR > x)$$

Where x is threshold

4. COMPANDING AND D-CAST TECHNIQUES

Companding means compresing and expanding .there are several companding algorithms have been proposed such as u-law companding and exponensial law companding etc.In this paper we are going to present a new companding algorithm which is non linear process.Estimation of OBI needs the awareness or knowledge about the signal power spectral density (PSD) of the signal which is companded. Let us assume c(x) is companding function and input x(t) = sin(wt) then after companding the signal will be

$$y(t) = c[x(t)] = c[\sin(wt)]$$

here y(t) and x(t) have same period .and fourier series of y(t) is expressed as

$$Y(t) = 1$$

where coefficients of a(k) will be calculated using

$$a(k\ ) = a(-k) = dt,\ T = .$$

input we are using here is a pure sinusoidal signal. So when a( ) = 0 for |k| is greater than 1 will be the OBI happened by the companding which is nonlinear process .so to reduce the OBI the solution is as k increases a(k) must be limited to zero.it will be continuously or infinitely differentiable. Here we are using sin(wt) and it is continuous function.so our companding function is differentiable infinitely .so we can minimise the OBI using this companding function. In this algorithm we are going to use a special companding function

$$c(x) = \beta \cdot sign(x) \cdot [aery(0) - aery(\alpha \cdot |x|)]$$

here aery(.) is ary function. α = degree of companding and it is the factor which controls the degree companding. β is the factor which is used to adjust the compander output power to the equal level of input average power. Mathematically β is represented as

$$\beta =$$

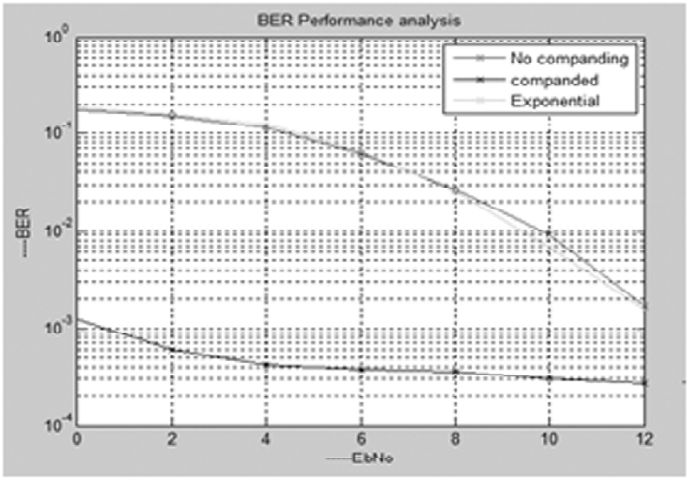

Figure 2: BER performance using companding.

The de companding function is obtained by inversing the companding function.

4.1. D-CAST method

In this paper we are going to introduce new algorithm which is performing very efficiently to reducing PAPR when compared to other techniques and giving improved BER. D_CAST means Discrete cosine and sine transform.Here we introduced a combination of Discrete Cosine and Sine Transform (D-CAST), which is based on Pre coding matrix to reduce the PAPR of the system.This Method is linear process.so it is easy to quantification of PSD(power spectral density).The D-CAST is a linear transform N-point D-CAST can be defined as

=

Where cas q = cosq + sinq for k = 0, 1, 2, 3, …… N-1

= cas ()

Where A is pre-coding matrix with size N × N. m and n are integers ranging 0 to N-1.

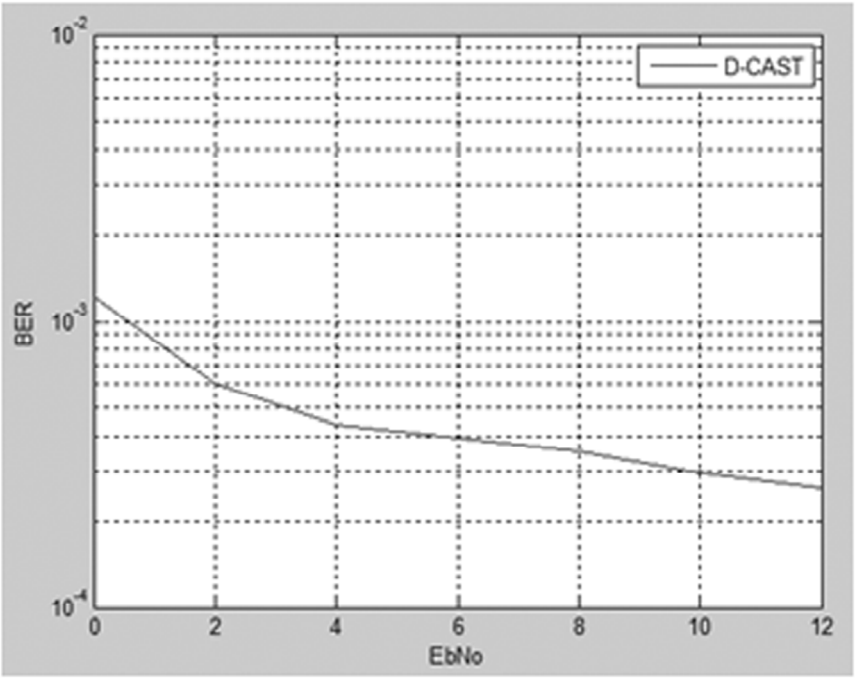

Figure 3: BER using D-CAST technique

The D-CAST is invertible transform.Its inverse form can be obtained just multiplying D-CAST by 1/N.

5. PERFORMANCE COMPARISON AND SIMULATIONS

In this OFDM system we used 16 QAM modulation. The IFFT/FFT SIZE IS 256. The number of sub carriers is 64.For companding technique we used input compander power is 3dbm, $\alpha = 30$.

In this paper we are taken other companding techniques u-law and exponential law for comparison purpose.By observing above results we can say that when we are not implemented any technique then PAPR is 12 db.new companding technique reduces this upto 4.2 db approximately.exponential law reduced it by 3.8 db approx.And finally our new D-CAST method reduced PAPR very effectively by 0.8 db.In case of BER companding and D-CAST produced improved results which are almost same .We observed that exponential companding law given better PAPR result than our new companding technique but it failed to

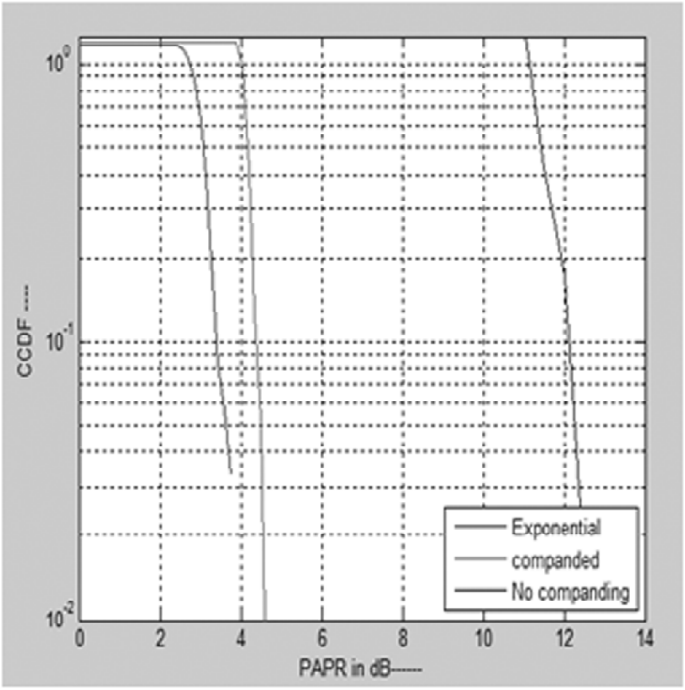

Figure 4: PAPR performance when using companding

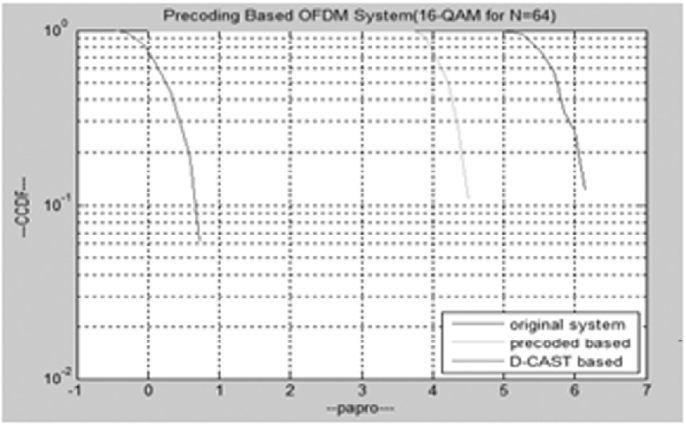

Figure 5: PAPR performance when D-CAST method

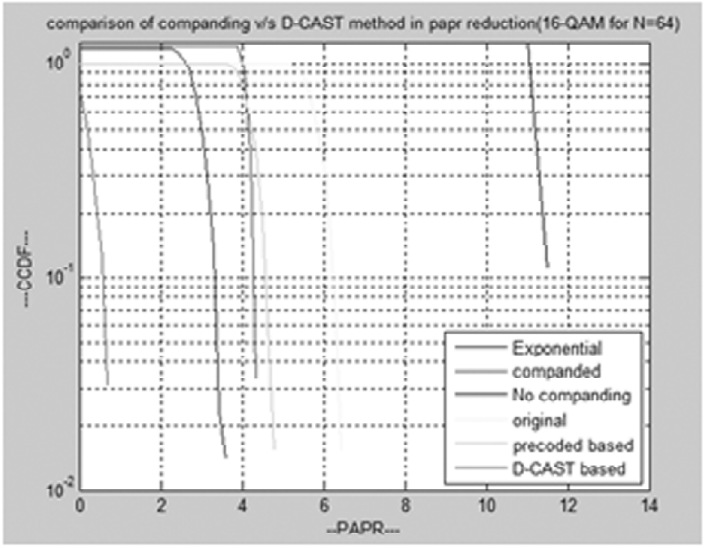

Figure 6: Comparison of PAPR performances between various methods

improve the BER.So in the aspects of BER and PAPR reduction new companding algorithm and our new D-CAST method are given improved results.when we compared these two methods D-CAST is better in the aspects of performance .

6. CONCLUSION

In this paper we have proposed a new D-CAST technique which offers a very efficient performance in the reduction of PAPR and improved BER when compared to other existing techniques. Because of linear transformation included, this process is easy to execute and analyses.

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