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A Novel Approach For Papr Reduction And Mitigating The Companding Distortion By Using Piece Wise Linear Companding Framework

Pokuru Naveen kumar[1] D.Srihari[2]

Department of ECE (DECS) [1], Associate professor M.tech[2]

Siddhartha educational academy group of institutions, Tirupathi, Andhra Pradesh, INDIA

Abstract

In the OFDM communication system the main disadvantage factor is Peak Average to Power Ratio (PAPR) which limits the performance of the overall system. To limit this factor in the OFDM system there are so many techniques are there, depends on the nature of the system like clipping, Partial transmission, Selective mapping, Companding transform etc, in these technique companding technique is the a simple methodology to compress or compand the input signal based on the inflection points to reduce the PAPR in the system, while decompander is the technique in the receiver to expand the companded signal from the transmitter section in the OFDM. The piecewise linear companding is based on the linear equations to compress the OFDM sequence where the companding distortion should considered, in this paper we present a efficient companding based on the piecewise linear equations. The whole system considered under ETU channel model. The simulation results show that a reduced PAPR and optimal BER rate of the OFDM system.

KEYWORDS: Piecewise linear companding, OFDM, PAPR, Power, Gain, AWGN channel

1. INTRODUCTION

OFDM system is Orthogonal Frequency Division Multiplexing system where the sub-carriers are orthogonal to each other. This indicates, non-overlapping of sub-carriers, which results in efficient spectrum utilization. Along with efficient spectrum utilization OFDM has high data rate as one of its advantages. But, due to emphasizing of sub-carriers in same direction high peaks are achieved resulting in high PAPR. This high value of PAPR destroys the orthogonality of the sub-carriers resulting in destruction of the OFDM system. Therefore, it is essential to reduce the PAPR value of the OFDM system. Various efforts are made to reduce PAPR value using different techniques. PAPR reduction techniques are basically classified as distorted and un-distorted techniques. The distorted techniques results in distortion but have no data rate loss while un-distorted techniques have distortion less data but results in data rate loss.

Large envelope fluctuation in OFDM signal is one of the major drawbacks of OFDM. Such fluctuations create difficulties because practical communication systems are peak power limited. Thus, envelope peaks require a system to accommodate an instantaneous signal power that is larger than the signal average power, necessitating either low operating power efficiencies or power amplifier (PA) saturation. In order to amplify the OFDM signal with large envelope fluctuations, PAs with large linear range are required, which makes it very expensive. If PA has limited linear range then its operation in non linear mode introduces out of band radiation and in band distortion. It is also necessary to have D/A and A/D converters with large dynamic range to convert discrete time OFDM signal to analog signal and vice versa. PAPR is generally used to characterize the envelope fluctuation of the OFDM signal and it is defined as the ratio of the maximum instantaneous power to its average power. In addition to this, OFDM system requires tight frequency synchronization in comparison to single carrier systems, because in OFDM, the subcarriers are narrowband. Therefore, it is sensitive to a small frequency offset between the transmitted and the received signal. The frequency offset may arise due to Doppler Effect or due to mismatch between transmitter and receiver local oscillator frequencies. The carrier frequency offset (CFO) disturbs the orthogonality between the subcarriers, and therefore the signal on any particular subcarrier will not remain independent of the remaining subcarriers. This phenomenon is known as inter-carrier interference (ICI), which is a big challenge for error-free demodulation and detection of OFDM symbols.

2. BASIC OFDM SYSTEM

The block diagram of OFDM system is shown in fig.1.The input high data rate streams are converted into number of low data rate streams. This parallel stream is then modulated using QPSK or QAM modulation techniques, which is then applied as input to IFFT block producing OFDM samples. These samples are then converted into OFDM signal using Parallel-to-Serial converter (P/S).The signal is then encoded by adding Cyclic Prefix (CP) and is then transmitted over the channel. The reverse process is done at the receiver

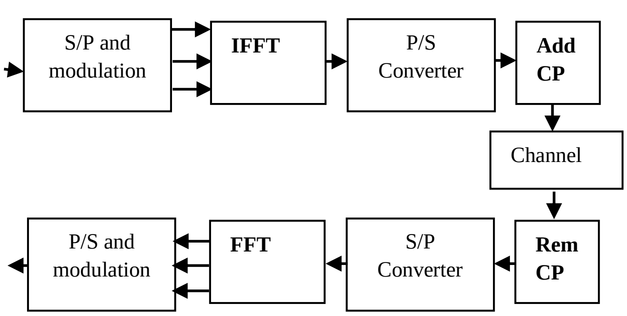

Figure 1: Block diagram of Basic OFDM system

3. PAPR REDUCTION TECHNIQUES

3.1 Clipping

The clipping is one of the simplest distortion based technique to reduce the PAPR of OFDM signal. It reduces the peak of the OFDM signal by clipping the signal to the desired level but it introduces both in-band distortion and out-of-band radiation. To limit out-of-band radiation and PAPR, Jean Armstrong proposed iterative clipping and filtering scheme.

3.2 Companding

Companding is another popular distortion based scheme for PAPR reduction in OFDM system. In another work Wang et al. proposed a scheme based on μ-law companding to reduce the PAPR of OFDM signal. In μ-law companding scheme the peak value of the OFDM signal before and after companding remains same, which keeps peak power of the OFDM signal unchanged but the average power of the OFDM signal after companding increases and therefore the PAPR of the OFDM signal gets decreased. But due to increase in the average power of the OFDM signal the error performance of μ-law companding scheme degrades.

3.3 Linear Companding Transform

Linear companding transform (LCT) has been proposed by Aburakhia et al. to reduce the PAPR of the OFDM signal. LCT also treats large and small signals on different scale but has two inflexion points to achieve more Flexibility in designing the companding function. The abrupt change in the transformed signal at inflexion point degrades the power spectral density (PSD). Trapezoidal companding (TC) proposed by Hou et al. is an efficient method to reduce the PAPR of OFDM signal with low BER. TC transforms the Rayleigh distributed magnitude of original OFDM signal to a trapezoidal distribution and called "Trapezoidal Companding". Trapezoidal companding utilizes a piecewise function defined in three intervals of OFDM signal magnitude.

3.4 Trapezium Distribution

Jeng et al. proposed trapezium distribution based companding (TDBC) to transform the Rayleigh distribution of original OFDM signal to biased linear distribution called "Trapezium distribution". All the companding schemes distort the shape of the original OFDM signal and PAPR reduction capability is achieved at the cost of BER performance degradation.

4. PAPR OF OFDM SIGNAL

The PAPR of OFDM signal represented in (1) is given by:

$$\text{PAPR}=\frac{\text{Peak power}}{\text{Average Power}}=\frac{max|x(t)|^2}{E[|x(t)|^2]}$$

Where E [·] denotes expected value. The value of PAPR is required to be as low as possible else the orthogonality of signal gets destroyed.

5. COMPLEMENTARY CUMULATIVE DISTRIBUTIVE FUNCTION (CCDF)

The performance evaluation of PAPR is done using the parameter named as Complementary Cumulative Distributive Function (CCDF). CCDF is defined as the probability by which the PAPR is greater than the threshold value of given PAPR0.

CCDF is mathematically represented as: CCDF = Pr [PAPR > PAPR0]

6. PROPOSED METHOD

6.1 New linear companding scheme

Based on the on top of design criteria for companding transform, a brand new piecewise linear companding theme is planned in this section. Then, with a theoretical analysis given, transform parameters are rigorously designed

6.2 Proposed Companding Scheme

When the initial signalx_n is companded with a given peak amplitude Ac, the proposed companding scheme shown in Fig.5 clips the signals with amplitudes over Ac for peak power reduction, and linearly transforms the signals with amplitudes close to Ac for power compensation. Then, the companding function of the proposed companding scheme is

$$h(x)=\begin{cases} x & |x| \le A_i \\ kx+(1-k)A_c & A_i < |x| \le A_c \\ sgn(x)A_c & |x| > A_c \end{cases} \qquad (1)$$

Where sgn(x is the sign function.

Consequently, the decompounding function at the receiver is

$$h^{-1}(x)=\begin{cases} x & |x| \le A_i \\ (x-(1-k)A_c)/k & (1-k)A_c < |x| \le A_c \\ sgn(x)A_c & |x| > A_c \end{cases} \qquad (2)$$

It is obvious that the proposed companding transform is specified by parameters A_c, A_iandk.Acis the peak amplitude of the companded signals. As the average signal power is maintained constant, then according to the definition of PAPR in (3), the PAPR value of the proposed scheme that can be achieved theoretically is determined by A_c. With a preset theoretical PAPR value, A_c can be determined asA_c =σ_x PAPR$10^{PAPR_{preset}/20}$. With determined A_c, parameters A_i andkcan be obtained by solving.

With acceptable manipulation, are often simplified into a equation about k. the details of the manipulation are shown in Appendix. With the premise of keeping the typical signal power constant, k has to be a positive real number smaller than one. Besides, to limit the peak amplitude of the distended signals not larger thanA_c,, ks hould not be a negative real number. Therefore, k is confined to the interval (0,1).

6.3 Companding Transform Parameter Selection Criterion

Aiming at minimizing Companding distortion, the selection criterion for the parameters of the proposed companding transform is derived in the sequel. The companding distortion of the proposed companding transform can be calculated as

$$\sigma_c^2 = \int_0^{+\infty} |y_n - x_n|^2 f_{|x_n|}(x)dx = \left((A_c - A_i)^2 e^{-\frac{A_i^2}{\sigma_x^2}} - \sqrt{\pi}\sigma_x A_c \left(erf\left(\frac{A_c}{\sigma_x}\right) erf\left(\frac{A_i}{\sigma_x}\right) \right) + \sigma_x^2 \left(e^{-\frac{A_i^2}{\sigma_x^2}} - e^{-\frac{A_c^2}{\sigma_x^2}} \right) \right) - \sqrt{\pi}\sigma_x A_c erf\left(\frac{A_c}{\sigma_x}\right) + \sigma_x^2 e^{-\frac{A_c^2}{\sigma_x^2}} \quad (3)$$

It can be seen from (22) that with a determined A_c, varies with k. Therefore, for each determined A_c, we formulate the problem of solving k as an optimization problem to mitigate companding distortion.

$$arg \min_{k \in R} \qquad \sigma_c^2$$

Subjected to: $a_2 k^2 + a_1 k + a_0 = 0, k \in [0,1)$,

$$and \quad A_c = \sigma_x e^{PAPR_{preset}/20}$$

Where the first constraint is the equation (26) derive Appendix. Shows the contour plot of the cost funct . As observed, the cost function is convex. Consequent we can find the optimal k which leads to the mini companding distortion for each determined A_c.

7. RESULTS

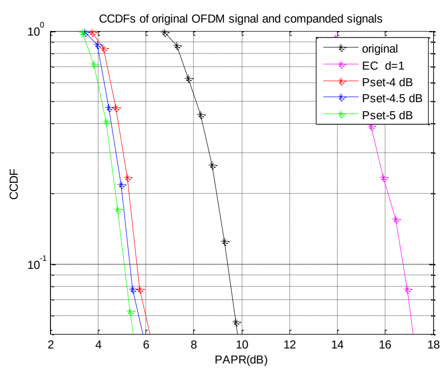

Figure 2: CCDF of original OFDM signal and companded signals

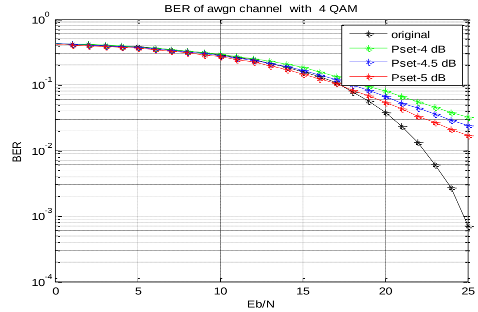

Figure 3: BER of AWGN channel with 4 QAM

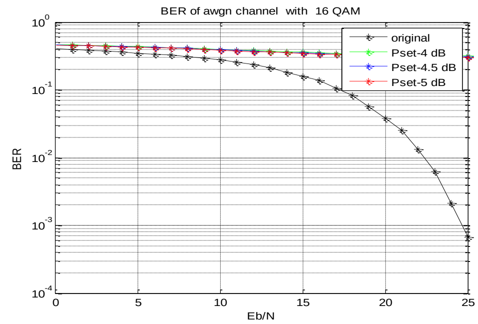

Figure 4: BER of AWGN channel with 16 QAM

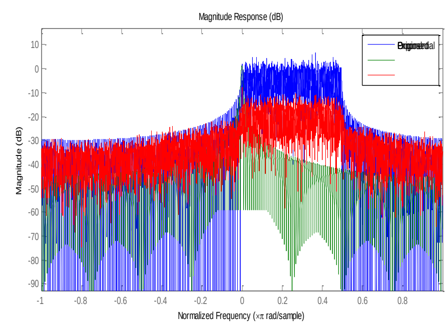

Figure 5: magnitude response

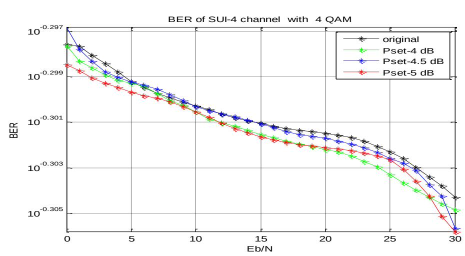

Figure 6: BER of SUI-4 channel with 4QAM

CONCLUSION

In our methodology the reduction of PAPR based on the companding transform with piecewise linear equations, the basic companding scheme introduces the distortion in the system which leads the system degraded results in the form of poor BER performance, PAPR as well. By our method we could make the system based on the optimal values of the different amplitude values called as inflection values. The proposed method with ETU channel implementation give the enhanced performance of the less PAPR and BER with mitigation of the companding distortion.

EXTENSION

PAPR Reduction is a challenging task in the orthogonal frequency division multiplexing, in our proposed work we use estimated power delay profile algorithm for channel estimation using additive white Gaussian noise channel. Estimation of channel estimation is done by using the AWGN with weights channel for better performance and low run time complexity.

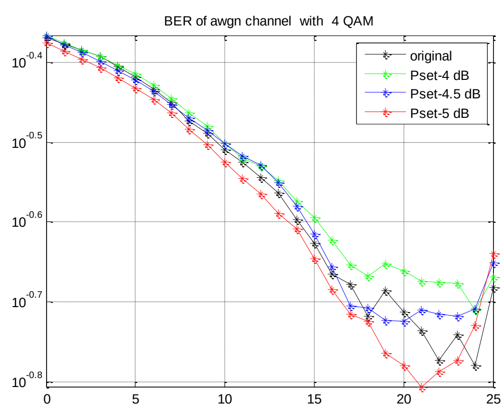

Figure 7: BER of AWGN channel with SUI MODEL

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