PAPR Reduction Method in OFDM System By Using Combined CAZAC Matrix Transform & Companding Technique

Authors
V. Ratna Kumari¹, Swathi Loya²

¹Assistant Professor in ECE Department, PVP Siddhartha Institute of Technology, Vijayawada, A.P, India
²M. tech Student, PVP Siddhartha Institute of Technology, Vijayawada, A.P, India

ABSTRACT
High Peak to Average power ratio (PAPR) is one of the major drawbacks in Orthogonal Frequency Division Multiplexing (OFDM). Among the various PAPR reduction techniques, Companding techniques appears attractive for its simplicity and effectiveness. This paper proposes a joint Companding transform and CAZAC matrix Transform based PAPR reduction technique. Simulation results show that the proposed scheme obtain significant PAPR reduction when compared to ordinary Companding method.

Keywords-Companding, OFDM, PAPR, CAZAC.

I. INTRODUCTION
Orthogonal Frequency Division Multiplexing have been extensively applied in wireless communication systems. OFDM based system provides great immunity to multipath fading and reduce complexity of equalizers. Rapid growth in multimedia based applications has triggered an insatiable thirst for high data rates and hence increase demand on OFDM based wireless systems that can support high data rates and high mobility.

As the data rate and mobility supported by OFDM system increase, the number of subcarriers required also increases, which in turn leads to high PAPR. Over the past decade various PAPR reduction techniques have been proposed, such as partial transmit sequence (PTS), selective mapping (SLM) [9] and tone reservation, just to name a few. Among all these techniques the simplest technique is to clip the transmitted signal when its amplitude exceeds a desired threshold. Clipping is a highly nonlinear process, however it produces significant out of band interference (OBI).

A good remedy for the OBI is the so called Companding. This technique cause far less OBI. This method was first proposed in [2],which employed the classical µ-law transform and showed to be rather effective, since then many different Companding transforms with better performance have been published.[5][7].

Constant amplitude zero auto correlation sequence (CAZAC) has good periodic correlation properties. Hence in this paper a joint Companding transform and CAZAC matrix transform based PAPR reduction technique is proposed for PAPR reduction.
in OFDM system which do not need any side information to be transmitted from the transmitter to the receiver. CAZAC matrix transform coding is used on the modulated data stream, then the N-point IFFT is applied. Finally, µ-law companding technique is applied and PAPR parameter is calculated for the obtained companded signal. The performance of CAZAC matrix transform coding is compared with hadamard matrix.

The organization of this paper is as follows. Section II presents the PAPR problem in OFDM systems. Companding, CAZAC matrix transforms and hadamard matrix transforms are introduced in section III, section IV and section V. In section VI, a PAPR reduction scheme by combining Companding and CAZAC matrix Transform is proposed. Simulation results are reported in section VII and conclusions are presented in section VIII.

II. SYSTEM MODEL

In this section, we review the basic OFDM transmitter and the PAPR definition. Consider an OFDM system as shown in Fig 1. Consisting of N subcarriers. Let a block of N symbols $x = \{X_k, \ K=0, 1 ... N-1\}$ is formed with each symbol modulating one of a set of subcarriers $\{f_k, \ k=0, 1...N-1\}$, the N subcarriers are chosen to be orthogonal. The complex baseband OFDM signal can be written as

$$x(t) = \frac{1}{\sqrt{N}} \sum_{k=0}^{N-1} X_k e^{j2\pi f_k t}, \ 0 \leq t \leq NT \ \ldots \ldots (1)$$

The PAPR of an OFDM signal $x(t)$, is the ratio of the maximum instantaneous power and its average power during an OFDM symbol.

$$PAPR = \max_{0 \leq t \leq NT} |x(t)|^2$$

$$\frac{1}{(NT)^2} \int_0^{NT} |x(t)|^2 dt$$

$$\ldots \ldots (2)$$

Reducing the $\max|\lambda(t)|^2 dt$ is the principle goal of PAPR reduction techniques

![Fig. 1 A simple block diagram of an OFDM system.](image)

We can evaluate the performance of PAPR, using the cumulative distribution of PAPR of OFDM signal. Cumulative distribution function (CDF) is one of the most regularly used parameters, which is used to measure the efficiency of PAPR technique. The CDF of the amplitude of a signal sample is given by:

$$F(z) = 1 - \exp(z) \ldots \ldots (3)$$

However, the complimentary CDF (CCDF) is used instead of CDF, which helps us to measure the probability that the PAPR of certain data block exceeds the given threshold. The CCDF of the PAPR of the data block is desired in our case to compare outputs of various reduction techniques. This is given by:

$$P(\text{PAPR} > z) = 1 - P(\text{PAPR} > z)$$

$$= 1 - (1 - \exp(-z))^N \ldots \ldots (4)$$

III. COMPANDING TRANSFORM

In this section we simply review the Companding transform. [2] The µ-law compander employs the logarithmic function at the transmitter end after IFFT operation. After Companding, the signal now becomes
\[ s(t) = C\{x(t)\} = \frac{V_x(t)}{\ln(1 + \mu V_x(t))} \ln(1 + \mu V_x(t)) \cdots (5) \]

Where ‘v’ is the average amplitude of signal and \( \mu \) is the Companding parameter. This transform reduces the PAPR of OFDM signal by amplifying the small signal and shortening the big signal.

IV. CAZAC SEQUENCE & ITS TRANSFORM MATRIX

An example of CAZAC [6] is given in Eq (6). Let \( L \) be any positive integer bigger than one, and let \( p \) be any number which is relatively prime to \( L \). Then the CAZAC sequence \( C = \{C_0, C_1, \ldots, C_{L-1}\} \) with length \( L \) is given as follows:

\[ C_k = \begin{cases} \exp\left(\frac{2\pi i k}{L}\right), & \text{if } L \text{ is odd} \\ \exp\left(\frac{2\pi i k^2 p}{L}\right), & \text{if } L \text{ is even} \end{cases} \]

Where \( k = 0, 1, \ldots, L-1 \).

CAZAC Matrix Transform: An \( N \times N \) complex orthogonal transform matrix \( A \) is constructed as an orthogonal matrix by rearranging CAZAC sequence with length \( L = N^2 \), \( P = 1 \) as follows.

\[ A = \begin{bmatrix} C_0 & C_N & \cdots & C_{N(N-1)} \\ C_1 & C_{N+1} & \cdots & C_{N(N-1)+1} \\ \vdots & \vdots & \ddots & \vdots \\ C_{N-1} & C_{2N-1} & \cdots & C_{N^2-1} \end{bmatrix} \]

The \( N \) length input vector, \( x = [X_0, X_1\ldots X (N-1)] \) is transformed by CAZAC matrix ‘A’ to get the vector, \( x(A) = [X (A0), X (A1)\ldots X (A (N-1))] \).

This vector is presented to the inverse FFT (IFFT) block. We use CAZAC sequence because it reduces the autocorrelation of the input sequence and this do not require any side information to be transmitted from transmitter side. The performance of the CAZAC matrix transform is compared with Hadamard matrix.

V. WALSH HADAMARD TRANSFORM

The Walsh Hadamard Transform (WHT) [3] is non–sinusoidal and it is an orthogonal technique which decomposed a signal into a set of basis functions, which are called as Walsh functions. The FWHT for a signal \( x \) of length \( N \) are defined as

\[ Y_n = \frac{1}{N} \sum_{i=0}^{N-1} x_i \text{WAL}(n,i) \]

Where \( i = 0, 1\ldots N-1 \) & WAL \((n,i)\) are Walsh functions.

VI. PROPOSED SCHEME

The coming input data stream is firstly transformed by CAZAC matrix transform. Then the transformed data stream is input to IFFT signal processing unit. The output of the IFFT signal is then companded.

VII. SIMULATION RESULTS

In this section we present the results of computer simulations used to evaluate PAPR reduction.
capability. In simulation an OFDM system with a sub carrier of N=64 & 16-QAM modulation was considered. The performance of the PAPR reduction scheme is evaluated using the CCDF of the PAPR of the OFDM signal. Fig.3 shows the PAPR comparisons of CAZAC transformed OFDM & conventional OFDM for 100 frames with oversampling factor=4.

Fig.3. PAPR comparison of CAZAC transformed OFDM & conventional OFDM

Fig.3 shows that the PAPR of CAZAC transformed OFDM signal is limited to smaller range than that of the original OFDM signal. Fig.4 shows the CCDF performance of the CAZAC matrix transformed OFDM scheme compared with that of the conventional OFDM and hadamard transformed OFDM. It shows that at CCDF=10^{−2}, the CAZAC transformed OFDM scheme reduces the PAPR by 2dB over conventional OFDM, but the hadamard transformed OFDM scheme reduced the PAPR by 1dB.

Fig.4 CCDF of the PAPR for the hadamard transformed OFDM and CAZAC transformed OFDM scheme.

From the figure 3 and 4 it is observed that CAZAC sequence is good in PAPR reduction of the OFDM signal.

Fig.5. CCDF performance of μ-law Companding (μ=3) & proposed scheme.

Fig.5 reveals that when CAZAC transformed OFDM signal is companded using μ-law Companding, at CCDF=10^{−2} the PAPR is reduced by 6dB over conventional OFDM, but PAPR is reduced by 5dB only when Companding technique itself is used. Therefore the proposed scheme can offer better PAPR reduction.
VIII. CONCLUSION

Companding techniques can solve the high PAPR problem for OFDM systems. In this paper a PAPR reduction algorithm based on CAZAC transform is investigated. This method provides good performance for PAPR reduction. Also CAZAC transformed scheme combined with μ-law Companding technique is proposed. The simulation results shows that the proposed method could offer better system performance in terms of PAPR reduction than the μ-law Companding scheme. Also CAZAC transformed scheme can be combined with other PAPR reduction techniques, such as SLM, block coding, and other Companding techniques, to get a better PAPR performance.

REFERENCE