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PAPR Reduction in OFDM by using a Companding on CSS Scheme

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Abstract - *An In recent time, the demand for multimedia data services has grown up rapidly. One of the most promising multi-carrier system, Orthogonal Frequency Division Multiplexing (OFDM) forms basis for all 4G wireless communication systems due to its large capacity to allow the number of subcarriers, high data rate and coverage with high mobility. OFDM is significantly affected by peak-to-average-power ratio (PAPR). Unfortunately, the high PAPR inherent to OFDM signal envelopes will occasionally drive high power amplifiers (HPAs) to operate in the nonlinear region of their characteristic curve. The nonlinearity of the HPA exhibits amplitude and phase distortions, which cause loss of orthogonality among the subcarriers, and hence, inter-carrier interference (ICI) is introduced in the transmitted signal. Not only that, high PAPR also leads to in-band distortion and out-of-band radiation. A partial transmit sequence (PTS) scheme is one of the typical PAPR reduction methods. A cyclic shifted sequences (CSSs) scheme is evolved from the PTS scheme to improve the PAPR reduction performance. However, as Companding transform is an extra operation after the modulation of OFDM signals, companding schemes reduce PAPR at the expense of increasing the Bit Error Rate (BER).*

***Key Words*: Cyclic shifted sequences (CSS), orthogonal frequency division multiplexing (OFDM), peak-to-average power ratio (PAPR), partial transmit sequence (PTS).**

1. INTRODUCTION

Orthogonal Frequency Division Multiplexing (OFDM) has been widely adopted technique because of its high spectral efficiency and robustness to frequency selective fading channel[1].However, OFDM system suffers from high Peak-To-Average Power ratio (PAPR) of the transmit signal. PAPR is defined as Peak power to Average power of a signal. The reason for the high peaks is the modulation itself, When multiple sinusoids are added together to form the multicarrier signal, these peaks are generated. The high peak power of the transmit signal will cause signal distortion, which results in Bit Error Rate (BER) degradation, out-of band radiation, increase the complexity of the D/A converter and reduce the power efficiency of the transmitter's power amplifier. Different techniques had been proposed in the literature to deal with the high PAPR problem[2] for OFDM system, such as clipping, coding, nonlinear companding, Selected Mapping (SLM)[3] , Partial Transmit Sequences (PTS)[6] ,Interleaving, Tone Reservation (TR), Tone Injection (TI), and Active Constellation Extension(ACE). Each of these techniques has a various cost for Bit Error Rate (BER) and the reduced PAPR. Among all existing techniques, the PTS method is best scheme due to its good performance of PAPR reduction without any distortion of transmitted signals. In PTS scheme the input sequence is separated into number of different sub blocks and after that those all sub blocks are converted into them into time domain by using Inverse Fast Fourier Transform (IFFT).Then, the PAPR minimization is achieved through multiplying the time domain sequences with complex phase factors. Motivated by success in reducing PAPR by using PTS the improved technique Cyclic Shift on PTS [4][5] is introduced. Cyclic Shift PTS is better than PTS because at the receiver side PTS requires side information about the phase factors. Coming to Cyclic Shift PTS, in these scheme in place of multiplication with phase rotation factor cyclic shifting is done on time domain OFDM sequences by a Shift Value. The Shift Value sets selection [8] directly relates to the PAPR reduction. To select the SV sets so many factors are to be considered. Those are type of partition is used to divide the input and amount of correlation remains after dividing the input sequence. To know the amount of correlation Auto Correlation Function (ACF) has to be considered and based on the ACF the criterions are discussed for selection of Shift Values. As earlier said that PAPR reduction depend on peak power and average power. The above technique reduces only peak value. So to improve the reduction performance here is a need of increasing average power also.

2. PROPOSED METHOD

The discrete-time transmitted OFDM signal is given by

$$x_n = \frac{1}{\sqrt{NL}} \sum_{k=0}^{NL-1} X_k e^{j2\Pi\frac{kn}{NL}} \quad , \quad 0 \le n \le NL$$

The PAPR of the transmitted signal can be expressed as

$$PAPR = 10\log_{10} \frac{\max(|x_n|^2)}{E(|x_n|^2)}$$

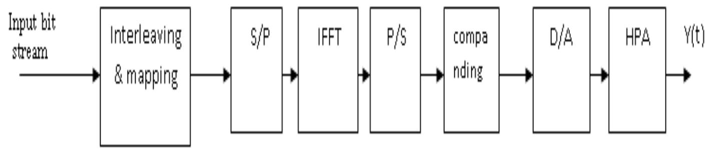

Fig.1. Block diagram of an OFDM system with companding.

Partitioning methods

There are 3 types of partitioning methods

1 .Interleaved partition

2 .Adjacent partition

3 .Random partition

Interleaved Partition

In this partition the input subcarrier (N) into (L) sub blocks for each one contains N/V contiguous subcarriers. The main idea of this operation breaks down the high correlation patterns of the input data frames on OFDM signal.

Adjacent partition

Adjacent partition is a simple method to implement the partition process, and its performance is better than the interleaving partition scheme. An adjacent partition scheme divides the sequence into (L) sub-block vectors similar to the interleaving partition scheme but each sub-block contains N/V of the consecutive subcarriers.

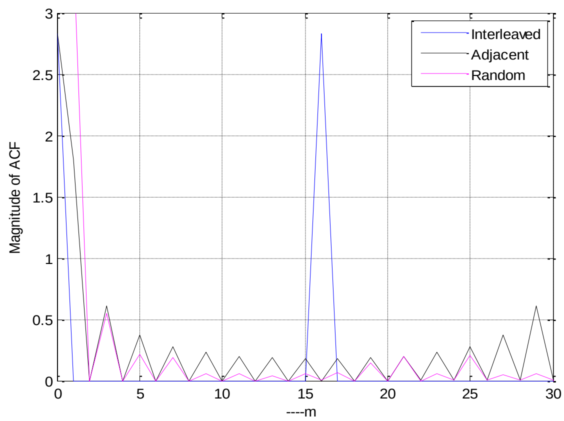

Fig. 2. Magnitude of ACFs for different partition cases

Random partition

Pseudo-random partition has the best PAPR reduction performance compare with interleaving and adjacent partition schemes. Each subcarrier can be randomly distributed on any position of the sub-block (L).

µ-law Companding

The United States and Japan use µ -law companding, µ-law Companding is one of the methods to reduce PAPR of OFDM signal by increasing the average power of the signal with less circuit complexity. In the µ-law Companding, the compressor characteristic is piecewise, made up of a linear segment for low level inputs and a logarithmic segment for high level inputs.

$$F(X) = \frac{\ln(1+\mu|x|)}{\ln(1+\mu)}\text{sgn}(x), \quad 0 \le |x| \le 1$$

3. RESULTS

Prior to verifying our proposed criteria for the CSS scheme, the comparison of the PAPR reduction performance between the conventional PTS scheme and the CSS scheme, where we re-confirmed that the CSS scheme shows a better PAPR reduction performance than the PTS scheme. For all the cases 16-quadrature amplitude modulation (16-QAM),and $V = 4$ are used. All the simulations are done by matlab.

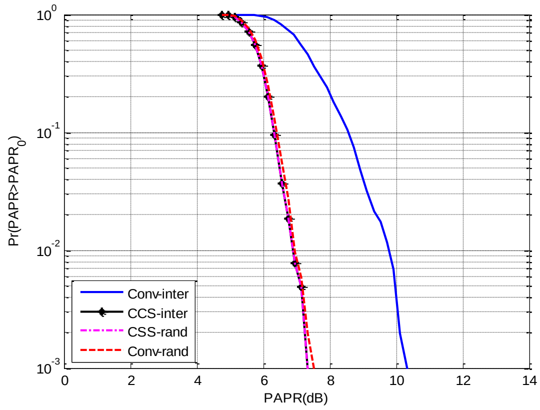

Fig.3.Comparison of the PAPR reduction performance between the conventional PTS scheme and the CSS scheme when $N = 64$

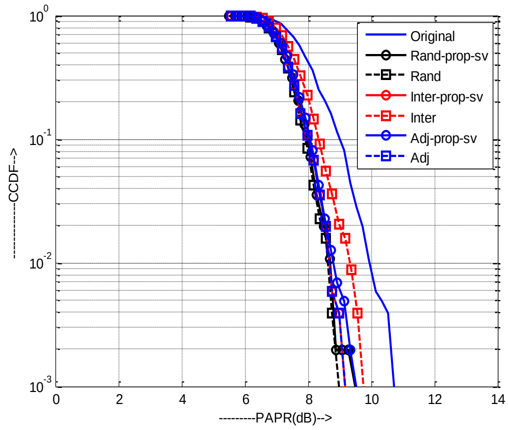

Fig. 4.Comparison of the PAPR reduction performance of the CSS scheme for three partition cases, which are random, interleaved, and adjacent partition cases when $N = 128$, $U = 4$, and $V = 4$ according to the used SV sets.

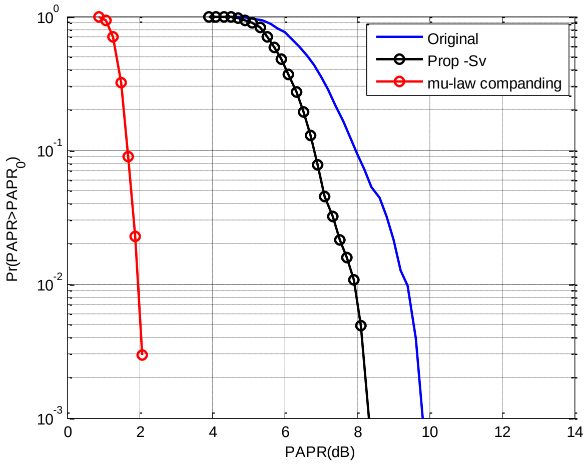

Fig. 5.Comparison of the PAPR reduction performance of the original OFDM, Proposed sv-sets and mu-law companding when N = 128, U = 4, and V = 4.

4. CONCLUSION

In this paper a new technique is proposed for PAPR reduction, which combines two classic PAPR reduction methods the cyclic shift PTS and the Companding method. The Companding technique use µ-law with suitable values of Input bit Stream µ. The simulations results prove that the performance of proposed method is better than the performance which can be obtained using only one of the two composing methods applied separately. This work can be extended by replace µ- law companding with other PAPR reduction techniques.

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