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Alternative Signal Generation in OFDM for PAPR Reduction by Using Piecewise Linear Companding

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Abstract---*In wireless communication, OFDM is used as LTE in today's generation. It provides high data rate, high speed and low complexity compared to conventional methods such as CDMA, TDMA and FDMA. Thus OFDM also offers some of the disadvantages such as PAPR, ICI and bit error rate etc,. mainly PAPR is occurred due to insufficient power spectrum. Thousands of techniques have been proposed to lower PAPR such as to improve spectral efficiency. To transmit signal in OFDM will preferred to have minimum PAPR for fixed peak power transmission higher average power is used. PTS provides better efficiency with reduced complexity. In proposed j method this PTS scheme is combined with the cyclic shifted sequences (CSSs) scheme to reduce the complexity by cyclically shifting the OFDM sequences and then combined to generate an alternative signal sequence which directly relates to PAPR reduction. In simulation results, the SV sets are carefully selected and its validation is approved by performing the simulations on the Selected SV sets. In future scope, piecewise linear companding technique is carried to improve the efficiency and data rate. Simulation results provide lesser complexity compared to the existing method.*

Index Terms --- Wireless Communication, OFDM, PAPR, PTS, SV sets, CSS, Piecewise Companding.

1. INTRODUCTION

In past years, the Communication industry has started focusing on fourth generation mobile communication systems.Now a days we have high demand for wireless application which have high speed data transmission. At present adaptable mobile applications have recently low date organizations are available. In multimedia applications the demand of high data rates is developing. OFDM is a stand-out one of multicarrier modulation, which segments the entire frequency selective fading channel into different orthogonal narrowband level flat-fading sub channels, to transmitting the higher rate data streams in parallel over various lower data rate subcarrier. For information transmission OFDM uses multiple narrow band subcarriers instead of using a single wide band subcarrier. A large number of closely spaced orthogonal subcarriers are used to carry data. The Orthogonality of the carriers means that each carrier has an integer number of cycles over a symbol period. And the spectrum of each carrier has a null at the center frequency of each of the other carriers in the OFDM system and results in no interference between the carriers. This allows the carriers to be separated as close as possible. And thus, the spectral efficiency is improved.

To transmit the data through OFDM for each subcarriers the data divided into several parallel data streams. Then the Quadrature Amplitude Modulation is applied for each subcarriers with low symbol rate. The total data rate in OFDM is maintained same bandwidth for every single subcarrier modulation method. In wireless communication system OFDM is best method for achieving better higher data transmission and multipath fading in systems. OFDM is a special form of multicarrier modulation which is particularly suited for transmission over a dispersive channel. Here the carriers are orthogonal to each other. That is the carriers are totally. independent of one another. One of the major challenging issues of OFDM is high peak-to-average power ratio. which is defined as the ratio of the maximum instantaneous power and its average power.

For information transmission OFDM uses multiple narrow band subcarriers instead of using a single wide band subcarrier.A large number of closely spaced orthogonal subcarriers are used to carry data. The Orthogonality of the carriers means that each carrier has an integer number of cycles over a symbol period. And the spectrum of each carrier has a null at the center frequency of each of the other carriers in the OFDM system and results in no interference between the carriers. This allows the carriers to be separated as close as possible. And thus, the spectral efficiency is improved.

A main problem associated with OFDM is its large peak to-average power-ratio (PAPR) that makes system functioning more sensitive to distortion introduced from nonlinear devices such as power amplifiers (PAs). In an attempt to decrease the nonlinear distortion caused by the PAs, numerous techniques have been proposed that can reduce the PAPR of the OFDM signal earlier it enters a PA. When OFDM signals with large PAPR pass through nonlinear high power amplifier, they experience in-band distortion & out-of-band radiation. OFDM signals with their high peak-to-average power ratios (PAPRs) require high linear amplifiers. Otherwise, performance degradation happens and out-of-band power requirement will be improved.

OFDM is known as modulation scheme and it acts based on the "Orthogonality principle". OFDM offers high data and supports advance applications. Although OFDM have advantages over traditional communication models frequently suffer from timing jitter, relative fading, distortion and PAPR. The presence of PAPR results in Gaussian distributed output samples in OFDM. Inter-modulation among sub-carriers and undesired Out-of-Band Interference (OBI) are the resultant of PAPR. PAPR presence has been an area of concern in OFDM and vast amount of research has been carried out using different techniques like Clipping and Filtering (CF), Tone Reservation (TR), Companding Transform (CT), etc. But none of the above techniques succeed in achieving the desired result.

Partial transmit sequences is one of the best method to reduce the PAPR in OFDM. Therefore, the OFDM signal is divide into number of sub blocks and then phase rotated sub blocks are added to generate the candidate signals. In this paper we implemented cyclic shift sequence evolved in PTS method in this method how to reduce the PAPR in OFDM sequences by selecting good SV Set values by considering the autocorrelation functions.

2.LITERATURE SURVEY

This survey presents a brief description of PAPR reduction in OFDM systems by adopting some of the PAPR techniques such as SLM and PTS. The drawbacks of the above two techniques are presented to evaluate the performance of OFDM in wireless communication system

The partial transmit sequence (PTS) is one the desired technique in reduction of high PAPR. Thus, the PTS technique is used to divide the data signal into some sub-blocks and each block is assigned by a specific phase factor. Since the search complexity increases effectively with the increase of number of sub blocks of the signal in OFDM system. Yajunwang (2010) has proposed Parametric Minimum Cross Entropy Method (PMCE) to search the optimal combination of phase factors. The PMCE algorithm is used to reduce the complexity as well as the irregular behaviour of the bits. Simulation results show that the performance of PTS is better when compared to conventional methods.

Chin-Liang Wang and Yuan Ouyang (2005) proposed a Selected mapping method (SLM). The SLM is also one of the efficiently used techniques in OFDM to reduce PAPR of a signal. SLM provides better result, but the thing is it requires of Inverse Fast Fourier Transforms (IFFTs) to generate a set of candidate transmission signals. Which leads to high computational complexity of the signal and this will result more Impact on the signal. In SLM two novel schemes were proposed with lesser complexity such as the first method uses only one IFFT block to generate the set of candidate signals, while the second one uses two IFFT blocks. The simulation results of both the scheme are nearly the same with less performance and data rate. Chin Liang wang continues his investigation by oversampling two times of the OFDM signals by applying peak search and partial interpolation method. The proposed scheme with two times oversampling has better PAPR estimation performance than the previous work without oversampling.

The comparison between SLM and PTS was proposed by Anil Singh Rathore and Neelam Srivastava (2010).They investigated that the SLM algorithm is more suitable if system can tolerate more redundant information, otherwise, PTS algorithm is more acceptable when complexity becomes the first considering factor.

3. Proposed Methodology

A. PAPR

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

$$\text{PAPR}=\frac{\text{Peak power}}{\text{Average Power}}=\frac{max\,|x(t)|^2}{E[|x(t)|^2]} \quad (1)$$

In OFDM Orthogonality will get destroyed in signal when the value of PAPR is high because of this we required low values of PAPR.Where E [·] denotes expected value.

B. Cyclic Shifted Sequences (CSS)

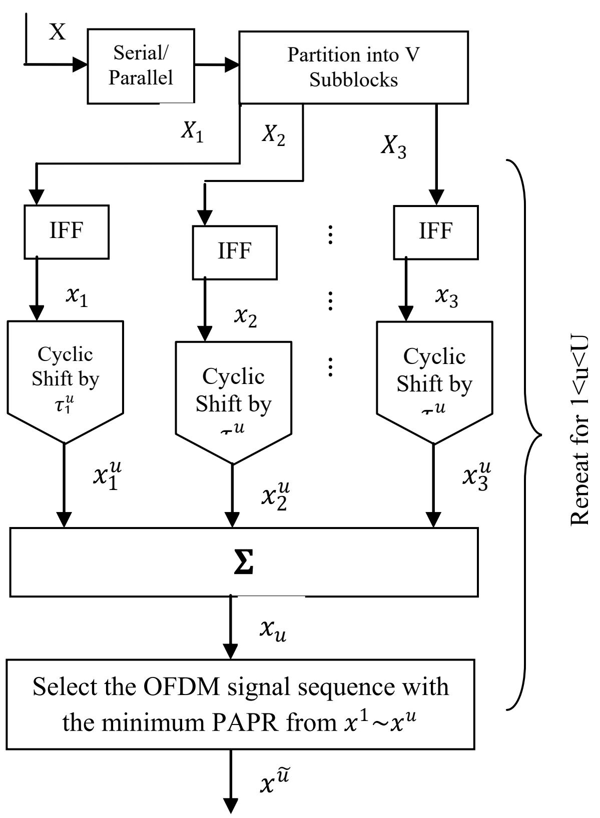

Fig.1: schematic diagram of the PAPR CSS scheme

As shown in the above figure, the CSS scheme procedure is described with a set of symbols. Firstly, the original signal *X* is converted into parallel form.Then divided into some fine partitions patterns named as *V*disjoint subblocks, input symbol subsequences *X1, X2, . . ., XV*. Then IFFT converts the *V* subblocks in frequency area to the V OFDM sign subsequences in time area x1, x2, . . .,xV, whereas*xv = xv(0), xv(1),. . . , xv(N − 1), 1 ≤ v ≤ V.*

For simplicity, we are going to assume both *N* and *V* are integers of power of two. After that, the *V* OFDM signal subsequences are cyclically shifted and combined for further processing onto make the u-th *(1 ≤ u ≤ U)* alternative OFDM signal sequence as,

$$x^u = \sum_{v=1}^{V} x_v^u \qquad (2)$$

Where, x_v^udenotes the leftward cyclically shifted version of xv by some integer τ_v^u (1 ≤ v ≤ V). That is,

$$x_v^u = \{x_v(\tau_v^u), x_v(\tau_v^u+1), \ldots\ldots, x_v(N-1), x_v(0), \ldots., x_v(\tau_v^u-1)\} \qquad (3)$$

The cyclic shift operation does not destroy the orthogonality between the input symbols X(k)'s because, as we all know, cyclic shifting in time domain is equivalent to multiplying a corresponding linear phase vector in frequency domain. As the SLM or PTS schemes, the candidate with all-time low PAPR,$x^{\tilde{u}}$, is chosen by thoroughgoing hunt for transmission with $\log_2$ U bits facet info. By mistreatment some extra techniques at the receiver, the facet info is often recovered.

In proposed paper we are denoting τ_v^u as a shift value as well as $\bar{\tau}^u = \{\tau_1^u, \tau_1^u, \ldots, \tau_V^u\}$ is the SV set for u-th alternative OFDM sequence. With the help of this we have to construct U SV sets as $(\bar{\tau}^1, \bar{\tau}^2, \ldots, \bar{\tau}^U)$ to implement the CSS.

CSS scheme will use 3 partition strategies, i.e., random, adjacent, and interleaved partition strategies. It is widely considered that the random partition technique offers the simplest PAPR reduction performance among them whereas the interleaved partition method offers the worst PAPR reduction performance however it wants the lowest machine quality.

C. Desirable Shift Value Sets In The CSS Scheme

In the CSS scheme, the PAPR reduction performance depends USV sets. The CSS theme is to minimize the probability of the PAPR prodigious some threshold level rather than to reduce the PAPR of each alternative OFDM signal sequence itself, we've got a bent to may say usually that U SV sets that build alternative OFDM signal sequences as statistically independent as possible can perform well.

A. Desirable Shift Value Sets of OFDM Signal Subsequence Components

In fact, the elements in an OFDM signal subsequence don't seem to be mutually independent, which can be shown within the next subdivision. However for currently, we have a tendency to assume that the components within the OFDM signal subsequences are unit reciprocally freelance for simplicity. That is, we have

$$E\left[x_{v_1}(n_1).\{x_{v_2}(n_2)\}^*\right] = \begin{cases}\sigma^2, & v_1 = v_2 and n_1 = n_2 \\ 0, & otherwise\end{cases} \quad (4)$$

where σ^2represents component power of an OFDM signal subsequence and $\{.\}^*$ denotes the complex conjugate.

We denote the correlation between the nth component of the ith alternative OFDM signal sequence and the mth component of the jth alternative OFDM signal sequence as

$$\rho_{i,j}(n,m) = E[x^i(n).\{x^j(m)\}^*] \quad (5)$$

It is shown that the correlation in (6) only depends on the time difference between n and m. That is, (6) can be expressed as

$$\rho_{i,j}(n,m) = E\left[x^i(n).\{x^j(n-\delta modN)\}^*\right] = \rho_{i,j}(\delta) \quad (6)$$

where $0 \le \delta \le N-1$.

In this case, we have

$$x^1 = \left\{\sum_{v=1}^{V} x_v(0), \sum_{v=1}^{V} x_v(1), \ldots, \sum_{v=1}^{V} x_v(N-1),\right\} \quad (7)$$

Also, using (4), x^2 by the SV set is expressed as

$$x^2 = \left\{\sum_{v=1}^{V} x_v(\tau_v^2), \sum_{v=1}^{V} x_v(\tau_v^2 + 1\, modN), \ldots, \sum_{v=1}^{V} x_v(\tau_v^2 + N - 1\, modN)\right\} \quad (8)$$

$$\rho_{1,2}(\delta) = E[x^1(n).\{x^2(n-\delta modN)\}^*] using (7)$$

$$= E[x^1(0).\{x^2(-\delta modN)\}^*]$$

$$= E\left[\sum_{v=1}^{V} x_v(0).\left\{\sum_{v=1}^{V} x_v(\tau_v^2 - \delta modN)\right\}^*\right] using (8)\&(9)$$

$$= \sum_{v=1}^{V} E\left[x_v(0).\left\{\sum_{v=1}^{V} x_v(\tau_v^2 - \delta modN)\right\}^*\right] using (5) \quad (10)$$

where the value of n does not affect $\rho_{1,2}(\delta)$, and thus we use n = 0. Using (5), the inner term in the equation (10) becomes

$$E[x_v(0).\{x_v(\tau_v^2 - \delta modN)\}^*] = \begin{cases}\sigma^2, & \tau_v^2 = \delta \\ 0, & otherwise\end{cases} \quad (11)$$

Then, using (10) and (11), we have

$$\rho_{1,2}(\delta) = \alpha_\delta \sigma^2 \quad (12)$$

D. ACF of OFDM Signal Subsequences

The v-th OFDM signal subsequence is x_v And then S_v is the discrete power spectrum of that OFDM signal. It is represented as below

$$S_v = \{p(0), p(1), \ldots, p(N-1)\} \quad (13)$$

Where p(k) =$E[|X_v(k)|^2]$, and the value of p(k) will have the worth of zero or one. Because, the modulation order of all the sub-carriers of the signal are equal. And also, the average power is set to one. If we consider one example, if the interleaved partition is employed, $S_1 = \{10101010\}$ *and then* $S_2 = \{01010101\}$when N=8 and V=2.

After applying inverse discrete Fourier transform (IDFT) to the S_v. We will get ACF $R_{x_v}(m)$ and the X_v is considered as the input symbol sequence and it is having N-N/V zeros in a certain pattern and with respect to this ACF $R_{x_v}(m)$ is going to have a specific shape. Here we are going to calculate only the magnitude of the ACF because in the OFDM signal sequence, high peak is closely related to the magnitude of the components.

1) For interleaved partition: Here S_v becomes as an impulse train having an interval of V. Then, the ACF will become change as the impulse train as [14] .

$$|R_{x_v}(m)| = \begin{cases} \dfrac{\sqrt{N}}{V} & if\ m = 0\ mod\ \dfrac{N}{V} \\ 0 & otherwise \end{cases} \qquad (14)$$

2) For Adjacent Partition: Here S_v becomes as a rectangular function having a width of N/V. Then the ACF will becomes the function as [14].

$$|R_{x_v}(m)| = \begin{cases} \dfrac{\sqrt{N}}{V} & if\ m = 0 \\ \dfrac{\sin(m\pi/V)}{\sqrt{N}\sin(m\pi/N)} & if\ m \neq 0. \end{cases} \qquad (15)$$

3) For Random Partition: here S_v Can be represented as a binary pseudo random sequence. Then the ACF is going to have the same shape of a delta function, but the components are close to zero except m=0.

In fig. 2 we can see the example of the magnitudes of ACFs with respect to the following spectrum when N=32 and V=2; $S_1 = \{1010 \ldots 1010\}$For an interleaved partition; $S_1 = \{11 \ldots 1100 \ldots 00\}$For an adjacent partition; $c = \{10010110011111000110111010000\}$For a random partition, which is a one zero padded m-sequence with length 31; Clearly, S_2 is a complement of S_1In every partition and the shapes of $|R_{x_v}(m)|$ For v=1 and v=2 are same.

4. RESULTS

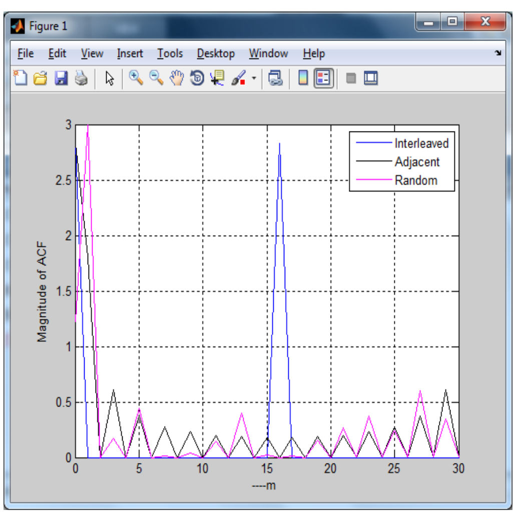

Fig.2: Performance of three different cases is compared under CSS scheme of PAPR reduction

Analysis: The performance of PAPR is evaluated for three different scheme such that to check which scheme performs better and provides high data rate.

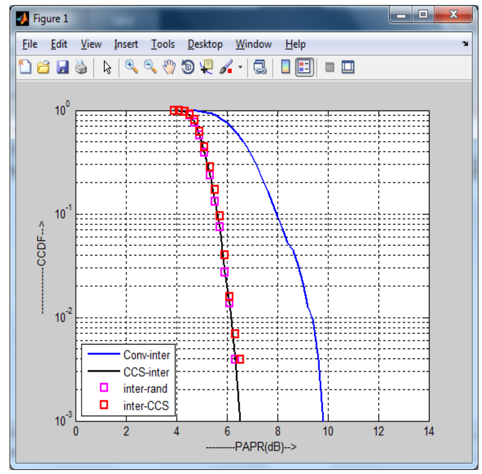

Fig.3: Comparison of the PAPR reduction performance of conventional and CSS scheme

Analysis: The performance PAPR is analyzed under conventional and CSS scheme for both random and interleaved partitions

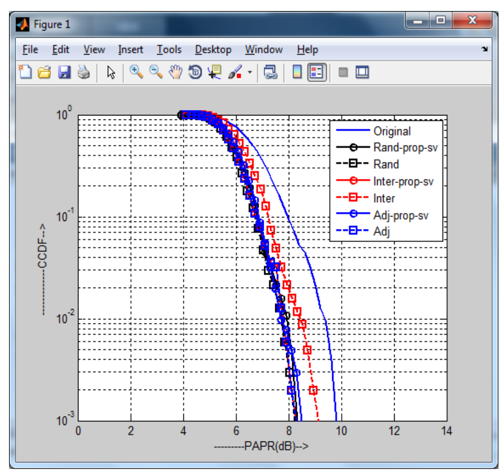

Fig.4: Comparison of the PAPR reduction performance of the CSS scheme for three partition cases, such as random, interleaved, and adjacent partition cases based on CCDF.

Analysis: the performance of PAPR at the receiver section is compared with the original signal at different schemes such as random, interleaved, and adjacent partition cases based on CCDF.

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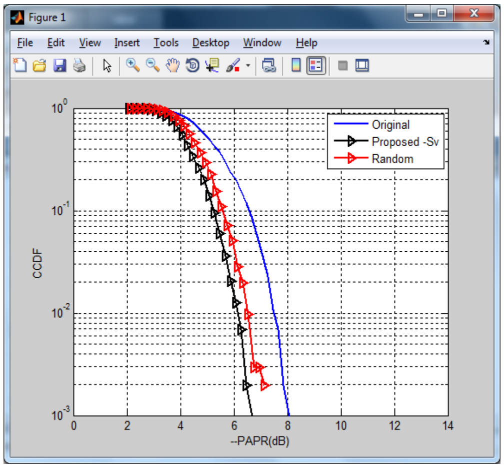

Fig.5: The optimality of the proposed SV sets

Analysis: this is used to analyse the performance of original signal with the CSS scheme as well as random partitioned signal.

Extension

PAPR Reduction is a challenging task in the orthogonal frequency division multiplexing, in our proposed method CSS scheme to reduce the PAPR.For better PAPR reduction further we implemented piecewise linear transform.

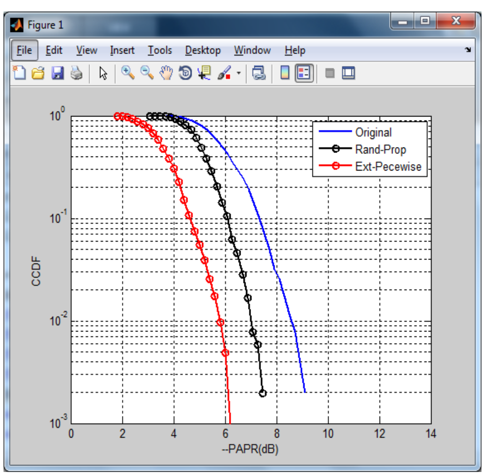

Fig 6:Comparision of PAPR reduction Original ,purposed and piecewise transform methods

Analysis: In the extension work, piecewise linear companding is used. Which is an advanced version of PAPR reduction scheme. Compared to proposed method this method provides lesser complexity and high data rate.

5. Conclusion

The CSS method is the extremely mainstream and promising PAPR reduction method, which is advanced from the PTS model. In this paper, the criteria to choose great SV sets are proposed, which can ensure the ideal PAPR reduction performance of the CSS method. The PTS scheme is combined with CSS scheme to reduce the complexity of a signal as well as to provide high data rate. The simulation results shows the improved performance of the signal when compared to conventional methods. In the extension work, piecewise linear companding technique is used to reduce PAPR when compared to proposed method, It achieves high data rate and robustness compared to proposed method.

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