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PAPR Reduction Using Low Complexity PTS to Construct OFDM Signal

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Abstract**—** Orthogonal frequency division multiplexing has become evident due to its higher frequency multiplicity to achieve high data rate and greater immunity to multipath fading. The imperative drawback of OFDM is its high peak-to-average power ratio which results in power inefficiency. There are numerous techniques used to overcome problem of high PAPR in OFDM modulation system. Partial transmit sequence (PTS) is most prominent peak-to-average power ratio (PAPR) reduction techniques proposed for orthogonal frequency-division multiplexing (OFDM) systems. The main drawback of the conventional PTS (C-PTS) is its higher computational complexity and transmission of several side information bits. A new PTS with simple detector is recommended here to deal with these drawbacks of C-PTS. The candidates can be generated by cyclically shift of each sub block sequence in time domain and combining them in a recursive manner. At the receiver, by using the natural diversity of phase constellation for different candidates, the detector can successfully regain the original signal without side information. The probability of detecting failure of the side information found that detector can work without any side information with high reliability. The scheme in this paper achieves almost the same bit error rate (BER) performance as the C-PTS with perfect side information, under additive white Gaussian noise (AWGN) channel and Rayleigh fading channel.

Keywords*- OFDM, PAPR, SQNR, PTS, DFT*

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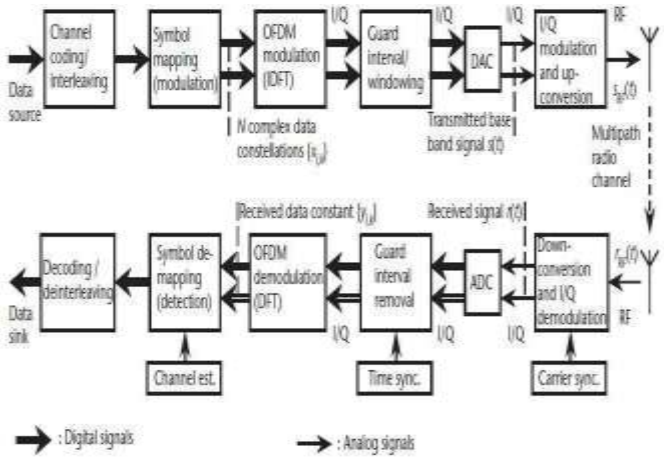
I. INTRODUCTION

The prime focus of wireless application is high data rates. The multi carrier transmission conception provides high data rate in communication channel. The OFDM is a special kind of multi carrier transmission technique that divides the communication channel into many equally spaced frequency bands. The concept of Partial Transmit Sequence (PTS) technique is applied to the OFDM symbols to reduce high peak signals. Coding and simulation are carried out for PTS and their effects on reducing the PAPR are find out.



Block Diagram of OFDM System

PAPR

PAPR is explained by its complementary cumulative distribution function (CCDF). PAPR is defined as the maximum power occurring in the OFDM transmission to the average power of the OFDM transmission. This technique is used to improve system performance.

$$\mathbf{PAPR} = \mathbf{P}_{peak} = \mathbf{max}\,[\,|X_n|^2]$$

$$\mathbf{P}_{average} = \mathbf{E}\,[\,|X_n|^2]$$

Where,

P_{peak} = **peak power of OFDM system**

$P_{average}$ = **average power of OFDM system**

A large PAPR increases analog – to – digital and digital – to – analog converter complexity and reduces the efficiency of the radio – frequency (RF) power amplifier. Regulatory and application constraints can be implemented to reduce the peak.

CCDF of PAPR

The cumulative distribution function (CDF) is most regularly used parameters, which are used for measuring the efficiency of any PAPR Technique.

The cumulative distributed function (CDF) of the signal is

$$\mathbf{F\,(z) = 1 - exp\,(z)}$$

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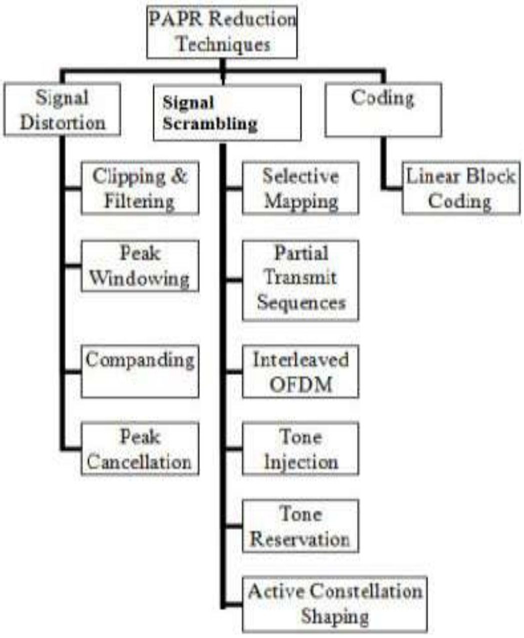
The complementary cumulative distributed function (CCDF) is used rather than CDF which helps us to measure the probability that the PAPR of a certain data block exceeds the given threshold.

P (PAPR > z) = 1 − P (PAPR ≤ z)
= 1 − F (z) N
= 1 − (1 − exp (−z)) N

II. PAPR Reduction Technique



A: Signal Distortion

1. ***Clipping & Filtering:***

In this process a threshold value of the amplitude is set and any sub-carrier having amplitude greater than that value is clipped or that sub-carrier is filtered to get a low PAPR value.

2. ***Peak Windowing:***

This process reduces PAPRs by increasing BER and out-of-band radiation. In this method multiplication of large signal peak with a specific window is done, for example; Gaussian shaped window, Kaiser and Hamming window.

B: Signal Scrambling Techniques

1. ***Selected Mapping***

Here set of different data blocks representing the information same as the original data blocks are selected. Selection of data blocks which have low PAPR value makes it suitable for transmission.

2. ***Partial Transmit Sequence***

3. ***Interleaving***

Perception that highly correlated data structures have large PAPR can be reduced, if long correlation pattern is broken down. The base idea of adaptive interleaving is to set an initial terminating threshold. PAPR value goes below the threshold rather than seeking each interleaved sequences.

4. ***Tone Reservation (TR)***

The main conception of this method is to keep a small set of tones for PAPR reduction. This is originated as a convex problem and this problem can be solved correctly by tone reservation method which is based on adding a data block and time domain signal. A data block is dependent on time domain signal to the original multicarrier signal to minimize the high peak.

5. ***Tone Injection (TI)***

This is based on additive method for PAPR reduction. By additive method a PAPR reduction of multicarrier signal without any data rate loss tone injection achieved. It uses a set of equivalent constellation points for an original constellation points to reduce PAPR.

C: Coding

1. ***Block Coding***

The fundamental perception of all probable message symbols is to choose only those which have law peak power. It can be chosen by coding as valid code words for transmission.

Many PAPR reduction techniques results in performance degradation in terms of BER comparison to original OFDM signal. The PAPR problem in OFDM is represented as an expression of one OFDM a symbol starting at t is represent as

$$S(t) = R_e\left\{\sum_{i=-\frac{N_s}{2}}^{\frac{N_s}{2}-1} d_i + Ns/2\exp(j2\pi\left(f_c - \frac{i+0.5}{T}\right)t - ts))\right\} ts \le t \le ts + T$$
$$S(t) = 0, t < s(t) = 0, t < ts + t$$

Where di are complex modulation symbols Ns is the number sub-carrier, T is the symbol duration and fc is the carrier frequency. According to DVB-T standard as the emitted signal represented as

$$S(t) = Re\ \{e^{j2\pi fct}\ \sum_{m=0}^{\infty} \sum_{l=0}^{67} \sum_{k=kmin}^{kmax} C_{m,l,k}\ \psi_{m,l,k}\ (t)\}$$
$$\psi_{m,l,k}(t) = \begin{cases} e^{j2\pi k(t-\Delta-l.T_s-68.m T_s)}\ else & (l+68.m).T_s \le t \\ 0 \le (l+68.m+1).T_s & \end{cases}$$

PAPR is usually defined as

$PAPR = Ppeak/Paverage$

$$PAPR = \frac{P_{peak}}{P_{average}} = 10log_{10}\frac{\max[|x_n|^2]}{E[|x_n|^2]}$$

$Ppeak$ shows peak output power $paverage$ means average output power denotes the expected value of xn which represents the transmitted OFDM signals. These are obtained by taking IFFT operation on modulation input symbol $\boldsymbol{xk}$ mathematical, $\boldsymbol{xn}$ is expressed as:

$$x_n = \frac{1}{\sqrt{N}}\sum_{K=0}^{N-1} X_K W_N^{nk}$$

In OFDM system with N sub-carrier, when the phase are same the peak power of received signal is N times average power.

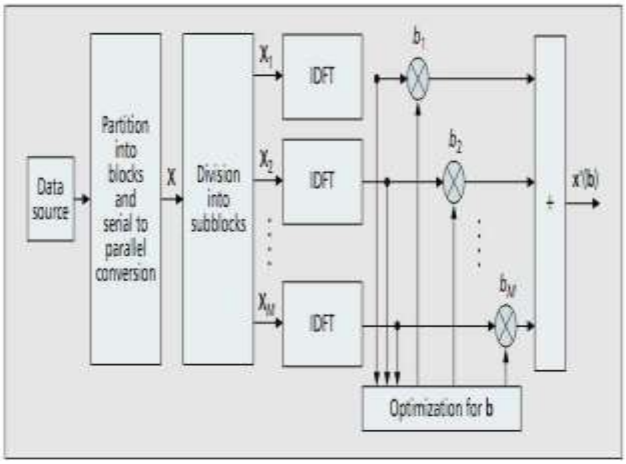
Comparison of PAPR Reduction Techniques-

Technique	Complexity	Distortion	Data Loss	Power Increase
Clipping	No	yes	no	No
Interleaving	No	no	yes	No
Coding	No	No	yes	No
Companding	No	No	yes	Yes
ACE	No	No	no	No
SLM	Yes	No	yes	No
PTS	Yes	No	yes	Yes
TR and TI	No	No	no	Yes

III. PAPR REDUCTION METHODOLOGIES

There are a number of techniques developed for PAPR reduction. The conventional PTS (C-PTS) is a assuring technique that can lessen the PAPR, while its complexity increases speedily as the number of sub blocks increases.

Partial Transmit Sequence (PTS)



Block diagram of Partial Transmit Sequence

In the PTS technique, an input data block of N symbols is divided into disjoint sub-blocks and then signal is transmitted. One more factor that can affect the PAPR reduction performance in PTS is the sub-block partitioning, this is the method of division of the subcarriers into multiple disjoint sub-blocks .There are three kinds of sub-block partitioning schemes-adjacent, Interleaved, pseudo-random partitioning. The PTS technique works with a random number of subcarriers and any modulation scheme. Advantage is that it works with an arbitrary number of subcarriers with any modulation scheme. But, this scheme comprises complexity and side information like SLM. The Partial transmit sequence (PTS) algorithm is a technique for improving the statistics of a multi carrier signal.

The basic idea of partial transmit sequences algorithm is to disunite the original OFDM sequence. In to several sub-sequence and for every sub-sequence multiplied by different weights until an optimum valve is chosen above diagram the block diagram of PTS technique .From the left side of diagram, the data information in the frequency domain X is separated into V non –over lapping sub-blocks and sub-block vector has the same size N. so for each and every sub-block it contain N/V non zero element and set the rest part to zero. Estimate that these sub-blocks have the same size and no gap between each other.

The sub-block vector is given by

$X{=}\Sigma v{=}1v\ bv\ xv$

Where the signal in time domain is obtained by applying IFFT operation on that is

$x = IFFT$

$X = \Sigma v = 1vbvIFFT$

$= \Sigma v = 1vbvXv$

For the optimum result one of the suitable factor from combination **b** = $[b1,2,\ldots..bv]$ is selected and the combination is given by

$b = b1,2,\ldots.,$

$bv = argmin\ b1,2,\ldots bv\ max1 \le n \le N$

$\Sigma v = 1vbvXv$

Where arg min [(.)] is the condition that minimize the output valve of function As a performance measure the complementary cumulative distribution function (CCDF) is one of the most frequently used for PAPR reduction techniques, which denotes the probability that the PAPR of a data block exceeds a given threshold z.

IV. PTS IN OFDM FOR PAPR REDUCTION

In PTS scheme all the subcarriers are split into multiple disjoint sub blocks and then each of sub blocks is multiplied by a set of rotating phase factors and combined to achieve a signal with lowest PAPR. The information about the phase factors by which these sub blocks/data symbols are multiplied, needs to forward to the receiver and this is known as side information (SI). SI has the highest importance as it is used to recover the original data signal. If SI gets corrupted then entire OFDM symbol block can be damaged and error performance of OFDM system reduces severely. In PTS technique, if number of sub blocks increases then increases computational complexity for selecting the optimum set of phase sequence as well as increases the amount of SI to be forward to the receiver. Because of SI there is a loss of data rate loss of data rate in OFDM system. The SI bits are extremely important for data recovery and it may be necessary to set aside few redundant bits to warrant accurate recovery of SI, but this operation will lead to again increase in the loss of data rate in OFDM system At the receiver, SI will extract from the OFDM signal which is received, and decoded to get the information about the phase factor which is used at the transmitter for minimizing PAPR. The demodulated signal is multiplied by the reciprocal of recovered phase factors, due to which the computational complexity at the receiving end gets increased. In most of the SI embedding schemes, at lower values of SNR the SI detection is very poor, because which the error performance of the OFDM system degrades acutely.

Existing SI embedding schemes eliminates the requirement of SI transmission but it suffers from one or more drawback, in terms of computational complexity, poor PAPR reduction capability and incorrect SI detection. In MPSM-PTS scheme it extends the QPSK constellation points to disjoint points of 16-QAM constellation and eliminates the requirement of side information. The MPSM-PTS scheme is completely free from SI that is separation of SI from the received signal is not required. Hence the structure of the scheme which is received is computationally less.

V. CONCLUSION

In this paper PAPR and its reduction techniques with PTS methodologies, an PTS scheme making use of the recursive combination of cyclically shifting sub-block sequences is represented. The proposed scheme will lower the complexity without side information. From the aspect of complexity, FFT can be implemented by the interleaved partition method. Then , no multiplication is performed by the cyclically shifting. The reduced complexity recursive method is used for generating new candidates. Finally, the overall detected number at the detector increases linearly with the number of sub-blocks rather than exponentially with the increase of candidates. When cyclic shift of the sub-block sequence is utilize, a set of candidates with different phase constellation will be generated according to the different shifting number of the sub block . As such, the detector can distinguish which candidates have been transmitted without any side information. Cyclically shifted sub-block sequences also increase the independence and the total number of candidates compared with the conventional PTS scheme. Simulation results have shown that the proposed scheme is reliable to estimate the selected shifting number of each sub-block. As a result, it achieves almost the same BER performance as the conventional PTS scheme but without any side information both in AWGN and rayleigh fading channels. It may be worthwhile to further study the performance of PTS in frequency selective channel without perfect channel information in the future complex.

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