ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 7, July 2014

An Efficient PAPR Reduction Method for LTE OFDM Systems

Sujay.S.N [1], Mamatha.M [2]

Assistant professor, Dept. of ECE, A.I.T College, Tumkur, Karnataka, India[1]

PG Student [DEC], Dept. of ECE, A.I.T College, Tumkur, Karnataka, India[2]

ABSTRACT: This paper reviews orthogonal frequencydivision multiple (OFDM) which has been adopted as a standard for various high data rate wireless communication systems. However, implementation of the OFDM system entails several difficulties. One of the major drawbacks is the high peak-to-average power ratio (PAPR) which cause large number of sub-carriers, that make restrictions for practical applications. Block Coding, partial transmit sequence and clipping are some PAPR reduction methods that have been proposed to overcome this problem. In this paper, we mainly investigate the PAPR reduction performance using interleaving & PTS, this method is sub-entities of interleaving & phase rotation scheme. A new algorithm using interleaving & PTS technique which shows better PAPR reduction compared to the existing algorithms is proposed. Results are verified using MATLAB software.

KEYWORDS: Orthogonal frequency division multiplexing (OFDM); partial transmits sequences (PTS); Interleaving ; peak-to average power ratio (PAPR).

I. INTRODUCTION

Long Term Evolution (LTE) is standardized by the 3rd Generation Partnership Project (3GPP) as an evolution of the 3G systems to meet the requirements of increasing the data rates, high mobility and low latency over a bandwidth of up to 20 MH.Researchers have been trying for the next evolutionary fourth generation (4G) communication systems to provide a comprehensive and secure IP solution where voice, data, and multimedia can be offered to users at "anytime, anywhere" with higher data rates than previous generations [1]. Multiple input multiple outputs (MIMO) and (OFDM) modulation have therefore been adopted due to their superior performance. These developing modulation used in LTE which promise to become the key for high-speed wireless communication technologies and combining them can provide wireless industry evolution from 3G to 4G systems. In OFDM systems which are use MIMO state that, the output is the superposition of multiple sub-carriers in this case,instantaneous power outputs increases and may demand higher powers than the mean power of the system since the phases of these carriers are the same. OFDM is multicarrier multiplexing access Technique for Transmitting Large data over Radio waves. One of the major drawbacks of OFDM signals is its large PAPR, which causes poor power efficiency to transmit amplifier`s power [16].And to reduce the PAPR, many techniques have been proposed, such as clipping, coding, PTS, selected mapping (SLM), interleaving[17][18], nonlinear companding transforms[14][19], hadamard transforms[20]. These schemes can mainly be categorized into signal scrambling techniques, such as PTS, and signal distortion techniques such as clipping, companding techniques, in this Paper all techniques which can be used to reduce PAPR in OFDM system are listed.

The outline for the paper is as follows: After system Structure, which is presented in Section II, definition of PAPR and its reduction techniques focusing on signal scrambling techniques specially (PTS) is investigated in section III, comprehensive analysis are conducted in terms of all possible influencing factors on PTS PAPR reduction performance and some research findings are reported based on the simulation results in section IV Finally conclusions of this paper are presented in section V.

II. BASIC STRUCTURE OF OFDM SYSTEM AND MIMO OFDM SYSTEM

Figure 1 shows the end-to-end block diagram of an OFDM system in which the discrete-time signal {X[n]} after

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applying IFFT at the transmitter can be expressed:

$$X[n]=\frac{1}{N}\sum_{K=0}^{N-1} X[k]\, e^{j\frac{2\Pi}{N}kn} \text{ ....(1)}$$

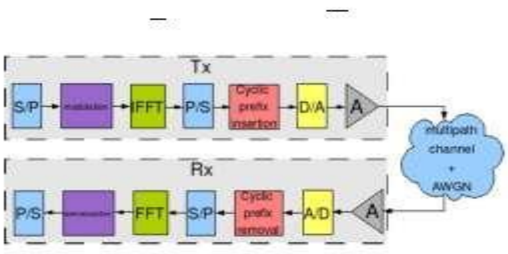

Fig 1: Block diagram of OFDM system

For a sequence of QPSK or QAM- modulated data symbols {X[k]}. In other words, X[n] is given by Adding the N different time-domain signals $e^{j\frac{2\Pi}{N}kn}$, each of which corresponds to the different orthogonal. subcarrier. The Kth one is modulated with data symbol $X[k]e^{j\frac{2\Pi}{N}kn}$.

III. PEAK-TO-AVERAGE POWER RATIO IN MIMO OFDM SYSTEM

The PAPR definition states that the instantaneous output of an OFDM system often has large fluctuations compared to traditional single-carrier systems. Ts requires that system devices, such as power amplifiers, A/D converters and D/A converters, must have large linear dynamic ranges. If this is not satisfied, the peak signal goes into the non-linear region of the device at the transmitter leading to high out of band radiation and inter-modulation distortion [2].Theoretically, large peaks in OFDM system can be expressed as PAPR. It is defined as:

$$PAPR = \frac{P_{Peak}}{P_{average}} = 10\log_{10}\frac{Max[|X_n|^2]}{E[|X_n|^2]} \quad (2)$$

Where

P_{peak} represents peak output power,

$P_{average}$ represents means average output power

Xn represents the transmitted OFDM signals & it can be represented as:

$$X_n=\frac{1}{\sqrt{N}}\sum_{k=0}^{-1} X_k\, W_N^{nk} \text{ ....(3)}$$

TABLE 1: Classification of PAPR techniques

PAPR techniques	
Signal scrambling techniques [4] [6]	Signal distortion techniques [14] [15]
Block coding	Signal clipping
Sub block coding	Peak windowing
Selective mapping	Envelope scaling
Partial transmit sequence	
Interleaving	
Linear block coding	
Tone reservation	
Tone injection	

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Vol. 3, Issue 7, July 2014

In this paper partial transmit sequence is focused on & PTS is most important methods used to reduce PAPR in OFDM system & it can be presented in two main presented in two main steps. First, by dividing the original OFDM signal into a number of sub-blocks. Secondly, adding the phase rotated sub-blocks to develop a number of candidate signals to pick the one with smallest PAPR for transmission.

There is another way that can also be used to express PTS method by multiplying the original OFDM signal with a number of phase sequences [13].

PTS technique partitions and input data block of N symbols into V disjoint sub-blocks as follows:

$X=[x^0 x^1 x^2, \ldots, x^{v-1}]^T$ …………………………………………………………………………………(4)

where $x^i$the subblocks that are consecutively located and are also of equal size, scrambling is applied to each subblock [11] which rotating its phase independently in the PTS technique as in Fig.4. Then each partitioned subblock is multiplied by a corresponding complex phase factor $b^v = e^{j\emptyset v}$ where v = 1,2,…….,V, subsequently taking its IFFT to yield:

$X=\text{IFFT}\{\sum_{v=1}^{V} b^v x^v\}=\sum_{v=1}^{V} b^v.\text{IFFT}\{x^v\} = \text{v} = \text{1Vbvxv}$……………………………………………………...(5)

Where $x^v$is referred to as PTS .The phase vectoris chosen so that the PAPR can be minimized [5], which is shown as:

$[b^{-1}, \ldots, b^v] = (\, max|\sum_{v=1}^{V} b^v x^v(\text{n})|)$

(6)

Where n=(0,1..N-1)

Figure 2 shows that the number of computations in this suboptimal combination algorithm is V, which is much fewer than that required by the original PTS technique which make (V<<W^v).Then the corresponding time-domain signal with the lowest PAPR vector can be expressed as:

x= $\sum_{v=1}^{V} b^v x^v$………………………………………………………………………………………(7)

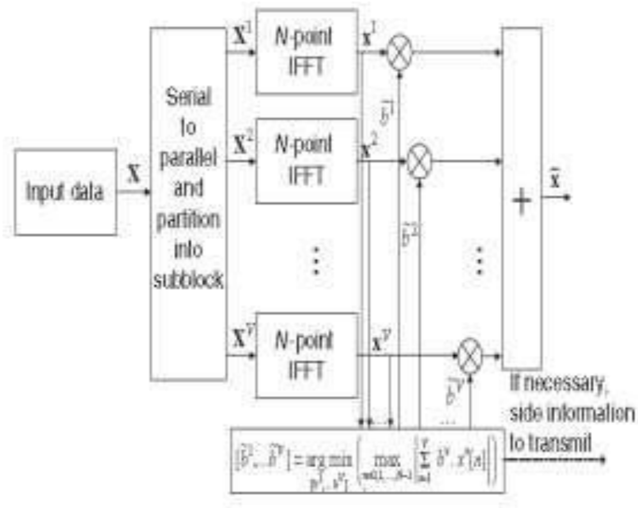

Fig.2 Block diagram of PTS technique for PAPR reduction

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IV. SIMULATION RESULTS

The following sections propose new techniques to create alternative sequences for PTS and shows through simulation that the peak regrowth of the proposed techniques after filtering is not as severe as in traditional PTS. This advantage is combined with reduction in complexity of the new algorithms as shown in flow chart in Fig.5.In this flow chart, new PTS suboptimal combination algorithm is introduced to get modified results for the complementary cumulative distribution function (CCDF) of OFDM signals.

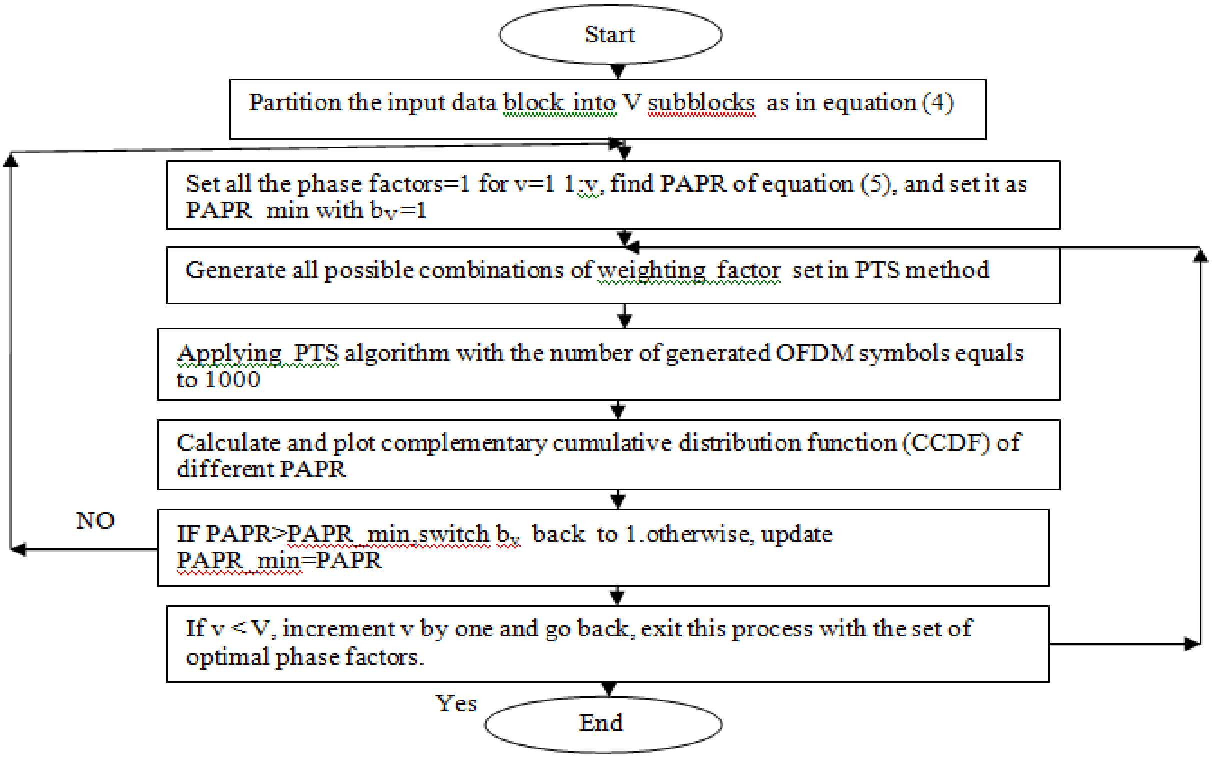
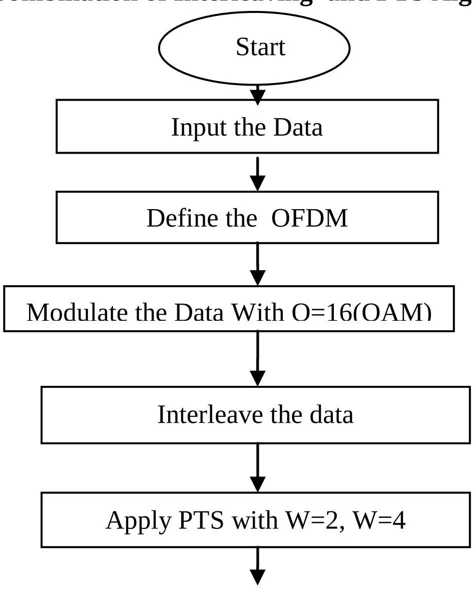


Fig.3 flow chart of PAPR Reduction performances in PTS method

Combination of Interleaving and PTS Algorithm:



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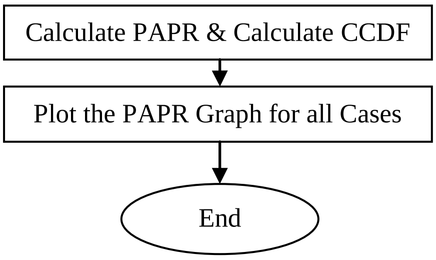

Fig.4 Flow chart of PAPR Reduction by using Combination of Interleaving PTS Method

TABLE 2

THE SYSTEM PARAMETER USED FOR SIMULATIONS

Parameters	Values used
Number of sub-carriers (N)	16, 128
Oversampling factor (OF)	8
Modulation scheme	QAM
Number of sub-blocks used in PTS methods (V)	2,4,8,16,32
Total number of combinations or IFFT for weighting factor 1 and 2	256
Number of generated OFDM Signal	10000

simplified CCDF will be used as:

$F_Z(Z) \approx (1-e^{Z^2})^{\alpha N}$……………………………………………………………………………………..(8)

where α has to be determined by fitting the theoretical CDF into the actual one [8]. Using simulation results, it has been shown that α= 2.8 is appropriate for sufficiently large N .

Figure 6 shows the CCDF of PAPR for a 16-QAM /OFDMA system using PTS technique as the number of subblock varies. It is seen that the PAPR performance improves as the number of sub blocks increases with V = 1, 2, 4, 8, and 16.

Fig.5 Input Image data for transmission CCDF of PTS PROPOSED Scheme

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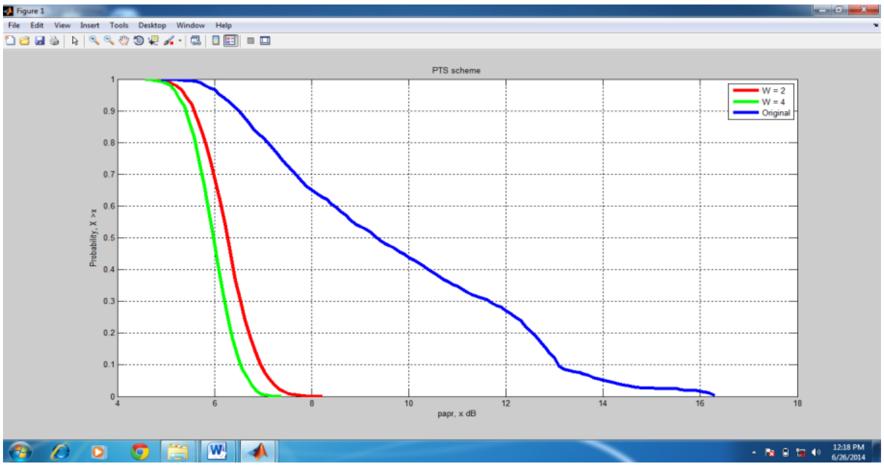

Fig.6 PAPR Of OFDM Signal with PTS Algorithm Implementation

As shown in Fig. 6. The original curve has PAPR equals to 16.5 dB.After applying to the proposed algorithms, the value was significantly reduced to 8.2 dB .This proves that the algorithm gives better results which is superior performance in PAPR reduction.

Fig.7 Input Image data for transmission

CCDF of combination of Interleaving and PTS Proposed Scheme

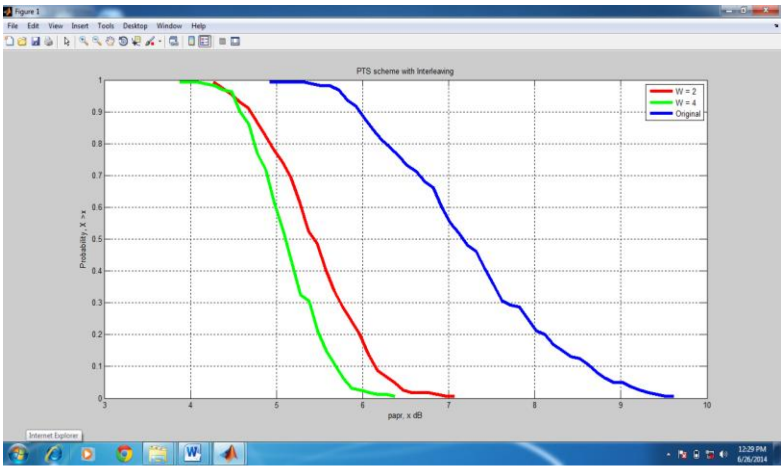

Fig.8 PAPR reduction performances of combination of Interleaving and PTS proposed algorithm

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ANALYSIS:

Table.3 Comparision Of PTS algorithm and Combination of Interleaving and PTSalgorithm In PAPR Reduction of OFDM Signal

PARAMETER	PAPR with PTS in dB	PAPR with Interleaving and PTS in dB	Reduction in PAPR using Interleaving and PTS in dB
Original OFDM Signal	16.2	9.5	6.7
W=2	8.2	7.1	1.1
W=4	7.4	6.4	1.0

V. CONCLUSION

This paper provides an overview of Orthogonal-Frequency-Division-Multiplexing (OFDM).The purpose of this paper was to reduce the High (PAPR) of OFDM signals. Using the proposed PTS algorithm, this was successfully achieved..A detailed simulations were conducted and results were obtained for PAPR reduction using Matlab. Using the above method, it was observed that the CCDF of OFDM signals were improved compared to other literature searches .In this paper both interleaving & PTS methods are combined and formed a new PTS Algorithm which shows better PAPRreduction compare to the existing PTS Algorithms.

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ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 7, July 2014

BIOGRAPHY

Mamatha.M (Mtech Student)