IOSR Journal of Electronics and Communication Engineering (IOSR-JECE)
e-ISSN: 2278-2834,p- ISSN: 2278-8735.Volume 11, Issue 3, Ver. I (May-Jun .2016), PP 96-99
www.iosrjournals.org

PAPR Reduction in QAM-OFDM System Using PTS with Increased Number of Phase Factors

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Abstract : *Orthogonal frequency division multiplexing (OFDM) is a multicarrier modulation scheme with high spectral efficiency and immunity to interference. The main drawback of OFDM system is the high peak to average power ratio (PAPR) of the transmitted signal which may result in signal distortion, loss of orthogonality in OFDM signals. Proposed method promises PAPR reduction in QAM-OFDM by using Partial Transmit Sequence (PTS) with new phase rotation factors when it is compared with existing PAPR reduction techniques such as conventional PTS, selected mapping, clipping and filtering. The MATLAB simulations show a PAPR reduction of around 1.5dB using the proposed method than the existing methods.*
Keywords: *Multicarrier modulation, partial transmit sequence (PTS), QAM-OFDM.*

I. Introduction

In Orthogonal frequency division multiplexing (OFDM) a single data stream is transmitted over a large number of lower rate carriers. The carriers are made orthogonal by appropriately choosing the frequency spacing between them. A major drawback of OFDM system is high PAPR. A large PAPR may result in the poor power efficiency, serious performance degradation, spectral regrowth and other challenges for its implementation when the power amplifier is used at the transmitter [1]. High PAPR needs significant power back off in a high power amplifier (HPA) to conserve the linearity of OFDM signals which results in power inefficiency. Thus high PAPR induces large power consumption and low battery life for mobile stations and high operating cost for base stations [2]. Main reason of occurrence of high PAPR in OFDM is due to addition of data symbols across a number of independent modulated sub-carriers with same phase [3].

The problem of PAPR and techniques to reduce it are discussed in many papers. Some of the techniques of PAPR reduction have been summarized [4]. Among the approaches proposed for PAPR mitigation, the PTS technique is very promising since it does not generate any signal distortion [5]. PAPR reduction using segmental PTS with different values of subblock partitions along with various oversampling factors is suggested [6]. Three kinds of PTS segmentation methods are there as adjacent, interleaved and random segmentation [7].The CCDF can be used to estimate the bounds for the minimum number of redundancy bits required to identify the PAPR sequences and evaluate the performance of PAPR reduction schemes [8]. Proposed method for PAPR reduction in QAM-OFDM system is using PTS technique with increased number of phase rotation factors.

II. Proposed Method

In OFDM, a block of N symbols,$\{X_n, n=0,1,...,N-1\}$ is formed with each symbol modulating one of a set of subcarriers,$\{f_n , n=0,1,...N-1\}$.The N subcarriers are chosen to be orthogonal that is $f_n= n\Delta f$, where $\Delta f = 1/NT$ and T is the original symbol period. The resulting signal is given by [9]:

$$x(t) = \sum_{n=0}^{N-1} X_n e^{j2\pi f_n t}$$

$$0 \leq t \leq NT \tag{1}$$

The PAPR of the transmitted signal in (1) is given by [9]:

$$\text{PAPR} = \frac{\max|x(t)|^2}{\text{E}[|x(t)|^2]} \tag{2}$$

Where E [.] represents expectation.

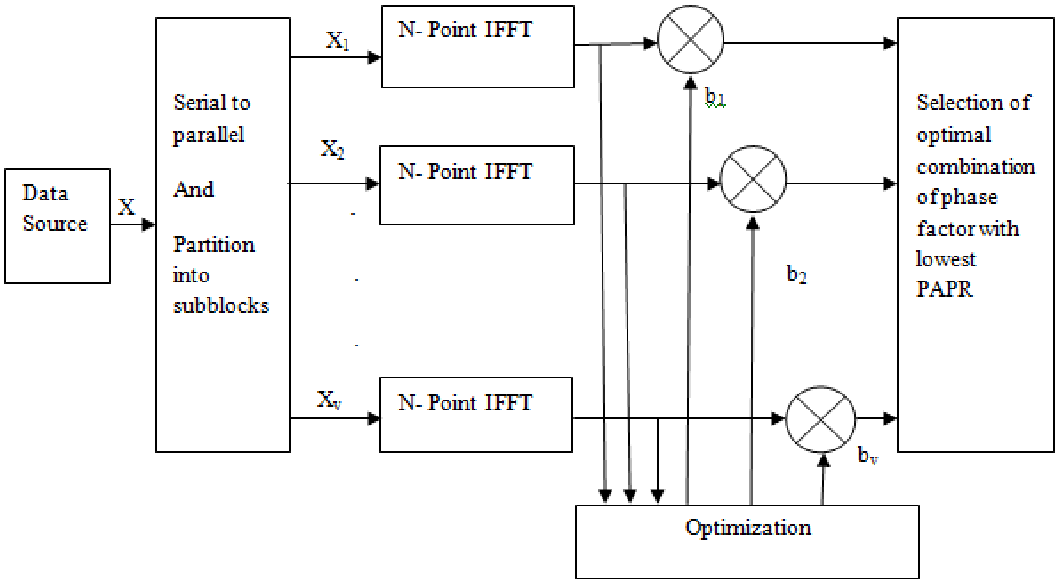

Fig.1. Partial transmit sequence scheme.

Partial Transmit Sequence (PTS) scheme is the PAPR reduction technique as shown in the Fig.1, in which, the input data block in X is partitioned into V disjoint subblocks, which are represented by the vectors $\{X_{v,}\ v=1,2,.....V\}$.Thus we can get:

$$X = \sum_{v=1}^{V} b_v X_v \tag{3}$$

Where $\{b_{v,}\ v=1,2,\ldots V\}$ are weighting factors.
In the time domain

$$x' = \sum_{v=1}^{V} b_v x_v \tag{4}$$

Where x_v, the IFFT of X_v is called as partial transmit sequence. These partial transmit sequences are independently rotated by phase factors. The phase factors are chosen to minimize the PAPR of x'. If we consider number of phase factors as W =2, then it indicates that there are two phase factors, one is in-phase & other is out-of-phase factor with phase factor set as {1,-1}. Like this only if we take W=4, then the phase factors set consists of {1,-1,i,-i} which indicates real & imaginary, in-phase & out-of-phase factors. In this paper adjacent partitioning scheme is used to partition subblocks, phase rotation factors are taken as {1,-1, i,-i}.
The complementary cumulative distribution function (CCDF) of the PAPR is used to compare and evaluate the performance of PAPR reduction technique in OFDM system. The CCDF denotes the probability that the PAPR of an OFDM symbol exceeds the given threshold PAPR0, which can be expressed as [10]:

$$\text{CCDF}\ (\text{PAPR}_0) = P_r\ (\text{PAPR}>\text{PAPR}_0) \tag{5}$$

In case of PTS technique the PAPR performance gets affected by various parameters such as, the number of subblocks, the number of the allowed phase factors also type of partition of the subblocks.As the number of subblocks increases the complexity of searching for the optimum set of phase vector increases.

III. Simulations Results

To evaluate the performance of the proposed method, simulations have been performed as per parameters shown in Table 1.

Table 1 Simulation parameters

Parameter	Value
Modulation	OFDM-QAM(with phase offset of 90 degree)
Number of OFDM symbols	10000
Number of subcarriers	1024
Number of sub blocks (V)	V=4,8
Oversampling factor (L)	L=2,4,6
Allowed phase factors (W)	4 i.e.(1,-1, i, -i)

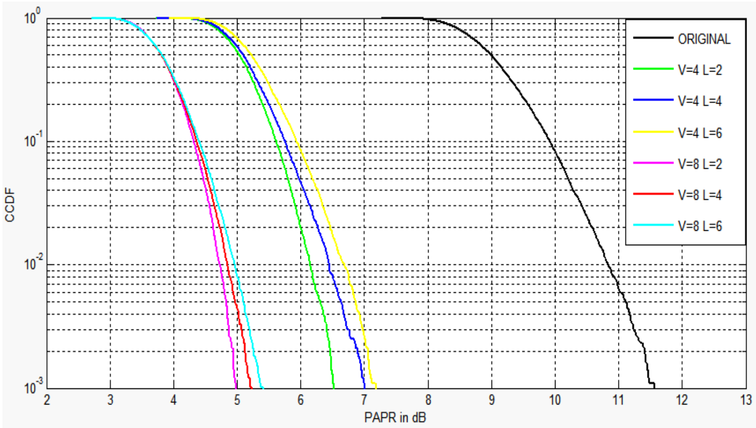

Fig.2. PAPR reduction of the proposed method with *V*=4 and *V*=8 with different values of *L*.

Fig. 2 shows the PAPR reduction of proposed PTS scheme for QAM-OFDM with *V*=4 and *V*=8, respectively. Increasing the number of phase factors to four [1,-1,i ,-i] along with *V*=8 provides PAPR reduction around 1.8dB when compared with *V*=4.

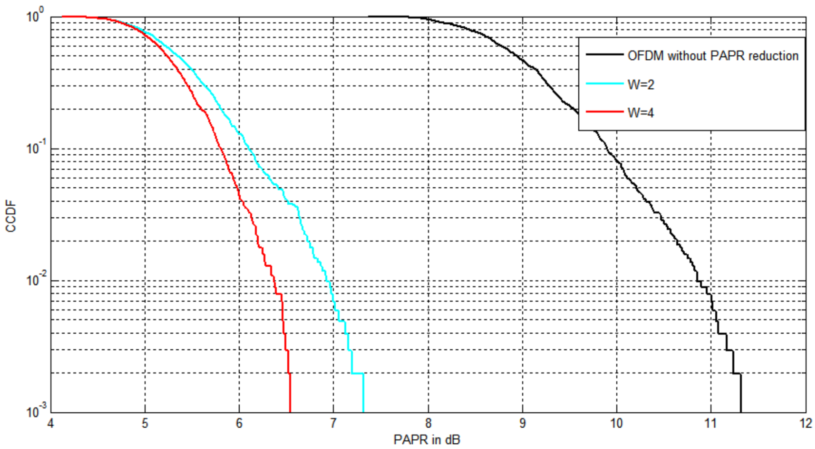

Fig.3. Comparison of PAPR performance of proposed PTS for QAM-OFDM with *W*=2 and *W*=4.

Fig.3. shows the comparison of CCDF of the PAPR based on number of phase rotation factors. The PAPR reduction capability of the PTS increases with the increase in the value of number of phase rotation factors 'W'. PTS with *W*=2 and *W*=4, achieve a PAPR reduction capabilities of 4 dB and 5 dB respectively, for a CCDF of 10^{-3}, over QAM-OFDM signal without PAPR reduction. The PAPR reduction capability of PTS for QAM-OFDM system with *W*=4 is more than that of with *W*=2 because for *V*=*W*=4 there are 64 alternative signals, whereas for *V*=4 and *W*=2 there are only 8 alternative signals. As the number of alternative signals is more the PAPR reduction is more.

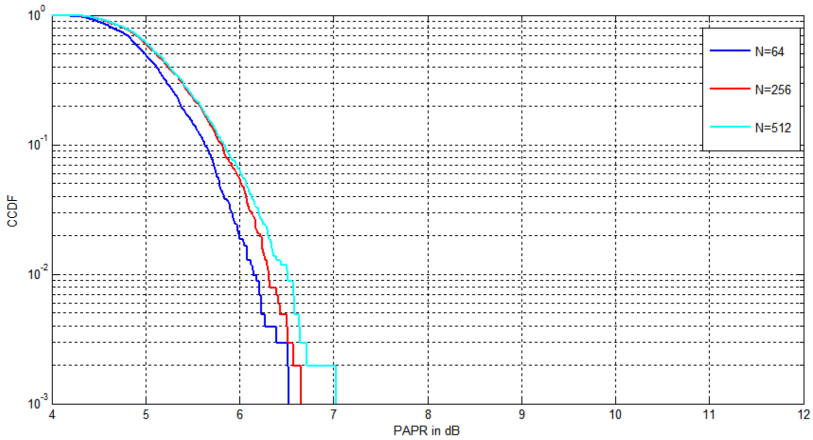

Fig.4. Comparison of PAPR performance of proposed PTS for QAM-OFDM system for different N.

Fig.4. shows the comparison of CCDF of the PAPR of the OFDM symbols for 64, 256 and 512 sub-carriers with QAM technique. PAPR is directly proportional to the total number of subcarriers (N). As number of subcarriers increases, the PAPR of OFDM system also increases and decreasing on number of subcarriers decreases the PAPR.

IV. Conclusion

In this paper, PTS with increased number of phase factors is proposed to reduce the PAPR of QAM-OFDM system. The simulation results showed that the proposed scheme could provide a better PAPR reduction performance than the QAM-OFDM system applying the PTS with conventional phase sequence. In this proposed scheme complexity increases due to increment of subblocks, number of selection of phase factors. In future the proposed PAPR reduction technique can be applied with multiple input multiple output (MIMO) OFDM system.

Acknowledgements

We convey our sincere thanks to the principal Dr. B. I. Khadakbhavi , dean of P.G. department Dr. V.G. Kasabegoudar and staff of MBES's College of Engineering, Ambajogai for help in carrying out this research work at the institute.

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