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A robust method in reducing the PAPR in OFDM using a hybrid SLM and PTS model

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ABSTRCT

The Orthogonal Frequency Division Multiplexing (OFDM) is an excellent and reliable technique for next generation wireless communication. Large Peak-to-Average Power Ratio (PAPR) is the one of the major drawback of the Orthogonal Frequency Division Multiplexing (OFDM) transmitted signal. In this paper, a new hybrid technique based on SLM and PTS scheme is presented to reduce the high Peak-to-Average Power Ratio (PAPR) of Orthogonal Frequency Division Multiplexing (OFDM) signals. We have compared the proposed technique with the SLM, PTS and Original schemes. Although all the others existing techniques like Partial Transmit Sequences (PTS), Selective Mapping (SLM) and Iterative flipping schemes can reduce the Peak-to-Average Power Ratio (PAPR), but the computer simulation results shows that the Proposed technique based on SLM and PTS scheme can offer better Peak-to-Average Power Ratio (PAPR) reduction than SLM, PTS, Iterative flipping techniques. But the proposed scheme is more complex than the existing techniques.

Keywords-Peak-to-Average Power Ratio (PAPR), Orthogonal Frequency Division Multiplexing (OFDM), Selective Mapping (SLM), Partial Transmit Sequences (PTS), Iterative flipping scheme, proposed scheme.

I INTRODUCTION

Orthogonal frequency division multiplexing (OFDM) technique is a very attractive technique for high bit transmission in a radio environment [1]. The high peak-to-average power ratio (PAPR) is the main drawback of the OFDM system, in which the OFDM transmitters require expensive linear amplifiers with wide dynamic range. Moreover, the amplifier non-linearity will cause inter modulation products resulting in unwanted out-of-band power and increased interference. Recently, many reductions PAPR have been proposed for OFDM system, as clipping [2] and peak windowing, block coding [3], scrambling [4], nonlinear companding transform schemes [5-6]; OFDM is an attractive technique for achieving high bit rate selective mapping [7-8] and phase optimization [9-13], and both are the most attractive ones due to their good system performance and low complexity.

Among these methods, partial transmit sequences (PTS) scheme is the most efficient approach and a least distortion-less scheme for PAPR reduction by optimally combining signal sub-blocks. In PTS technique, the input date block is broken up into disjoint sub-blocks. The sub-blocks are multiplied by phase weighting factors and then added together to produce alternative transmit containing the same information. The phase weighting factors, which amplitude is usually set to 1, are selected such that the resulting PAPR is minimized. The number of allowed phase weighting factors should not be excessively high, to keep the number of required side information bits and the search complexity within a reasonable limit. However, the exhaustive search complexity of the ordinary PTS technique increases exponentially with number of sub-blocks, so it is practically not realizable for a large number of sub-blocks. To find out a best weighting factor is a complex and difficulty problem.

The advent of evolutionary computation has inspired new resources for optimization problem solving, such as the optimal design of code division multiple access (CDMA) and fuzzy system. In contrast to traditional computation systems which may be good at accurate and exact computation, but have brittle operations, evolutionary computation provides a more robust and efficient approach for solving complex real world problem. Many evolutionary algorithms, such as Genetic algorithm (GA) [14-15], ant colony optimization (ACO) [16], simulated annealing (SA) [17] and particle swarm optimization (PSO) [18-24], have been proposed. GAs is stochastic search procedures based on the mechanics of natural selection, genetics, and evolution. Since they simultaneously evaluate many points in the search space, they are more likely to find the global solution of a given problem. PSO is a population-based stochastic optimization technique based on the movement of swarms and inspired by social behavior of bird flocking or fish schooling. Compared with GA [14] [15], PSO has some attractive characteristics. It has memory, so the knowledge of good solutions is retained by all particles; whereas in GA, previous knowledge of the problem is destroyed once the populations changed. It has constructive cooperation between particles, particles in the swarm share information between them. In this paper, we present a novel approach to tackle the PAPR problem to reduce the complexity based on the relationship between the phase weighting factors and the sub-block partition schemes. Specifically, we apply the PSO to search the optimal combination of phase factors with largely reduced complexity. Numerical results show that the proposed scheme can achieve better PAPR reduction with lower computational complexity compared with that of the GA approaches.

The rest of this paper is organized as follow. In Section 2, definition of PAPR of OFDM system and the principles of PTS techniques are introduced. The particle swarm optimization algorithm based PTS OFDM system has been examined in Section 3. Section 4 provides some performance results and a comparison of the proposed method with related work. Some conclusions are given in Section 5.

Orthogonal Frequency Division Multiplexing (OFDM) has many advantages and it is robustness against the frequency selective fading channel. Due to many advantages like multiuser diversity and robustness against frequency-selective fading, OFDM technique has been widely used in many wireless communication systems, such as Digital Audio Broadcasting (DAB), and the IEEE 802.11a standard for Wireless Local Area Networks

(WLAN), and the IEEE 802.16a standard for Wireless Metropolitan Area Networks (WMAN) [1]. For an OFDM system with N sub-carriers, an oversampling rate of L can be achieved by inserting $(L-1)\cdot N$ zeros in the middle of the modulated symbol vector to form a $1\times LN$ data

vector **X**, i.e.

$$\mathbf{X}=\left[X[0],\ X[1],\ \cdots,\ X[N/2-1],\ \underbrace{0,\ \cdots,\ 0}_{(L-1)N},\ X[N/2],\ \cdots,\ X[N-1]\right]$$

The PAPR computed from the L-times oversampled time-domain signal samples is given by

$$PAPR=\frac{\max\limits_{0\le k\le LN-1}\left|x_k\right|^2}{E\left[\left|x_k\right|^2\right]}$$

1.1 The CCDF of the PAPR

The cumulative distribution function (CDF) of the PAPR is one of the most frequently used performance measures for PAPR reduction techniques. In the literature, the complementary CDF (CCDF) is commonly used instead of the CDF itself. The CCDF of the PAPR denotes the probability that the PAPR of a data block exceeds a given threshold. From the central limit theorem, the real and imaginary parts of the time domain signal samples follow Gaussian distributions, assuming each distribution with a mean of zero and a variance of 0.5 for a multicarrier signal with a large number of subcarriers. Hence, the amplitude of a multicarrier signal has a Rayleigh distribution, while the power distribution becomes a central chi-square distribution with two degrees of freedom. The CDF of the instantaneous power of a signal sample is given by The CCDF of the PAPR of a data block with Nyquist rate sampling is derived as this expression assumes that the N time domain signal samples are mutually independent and uncorrelated.

Methods of reducing PAPR

Distortion : Clipping, Companding techniques.

Distortion less : Selected Mapping (SLM),Partial Transmit Sequence (PTS)

Others : Active Constellation Extension (ACE),Tone Reservation (TR)

Here we are suggesting a new method which improve both.

II SELECTED MAPPING AND PARTIAL TRANSMIT SEQUENCE

2.1 SLM(Selective Mapping)

1. A set of U markedly different, distinct, pseudo-random but fixed vectors $\mathbf{P}^{(u)} = [P_0^{(u)},\ldots, P_{N-1}^{(u)}]$, with

$$P_n^{(u)}=e^{+j\varphi_n^{(u)}},\varphi_n^{(u)}\in[0,2\pi),$$ must be defined.

2. The subcarrier vector **A** is multiplied subcarrier-wise with each one of the U vectors $\mathbf{P}^{(u)}$, then resulting to component

3. Then all *U* alternative subcarrier vectors are transformed into time domain to get and finally that transmit sequence with the lowest PAPR is chosen.

4. For implementation, the SLM technique needs *U* IDFT operations, and the number of required side information bits is ,denotes the smallest integer that exceed *y*.

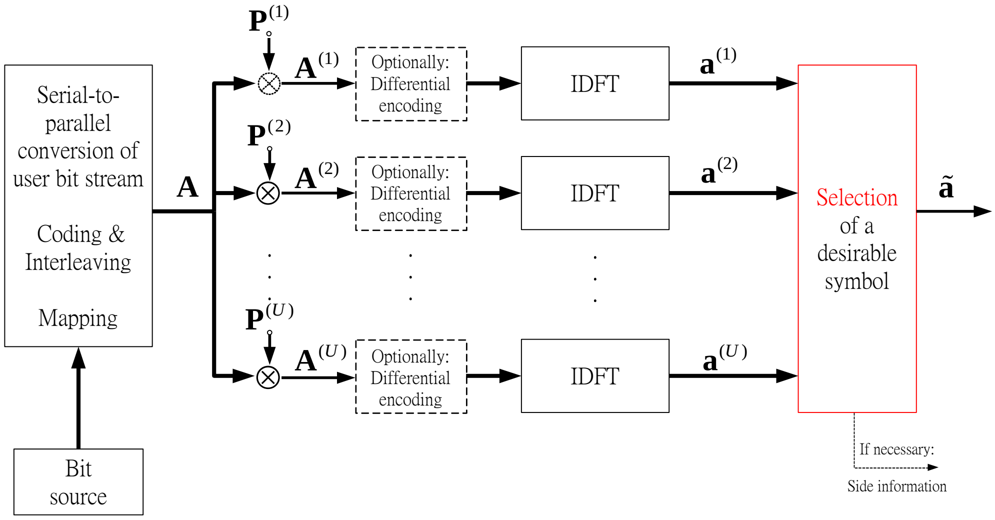

Figure 1:Selective mapping block diagram

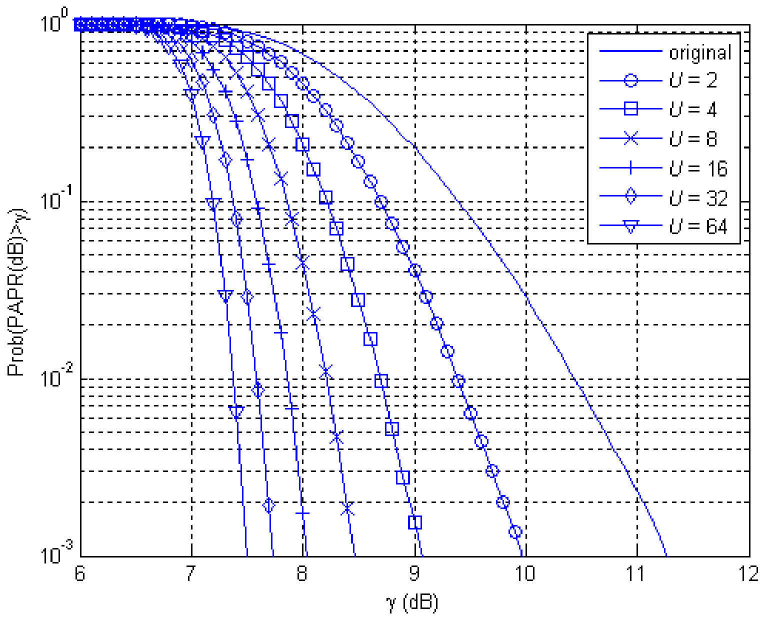

Figure 2 : PAPR Reduction using SLM

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2.2Partial Transmit Sequence

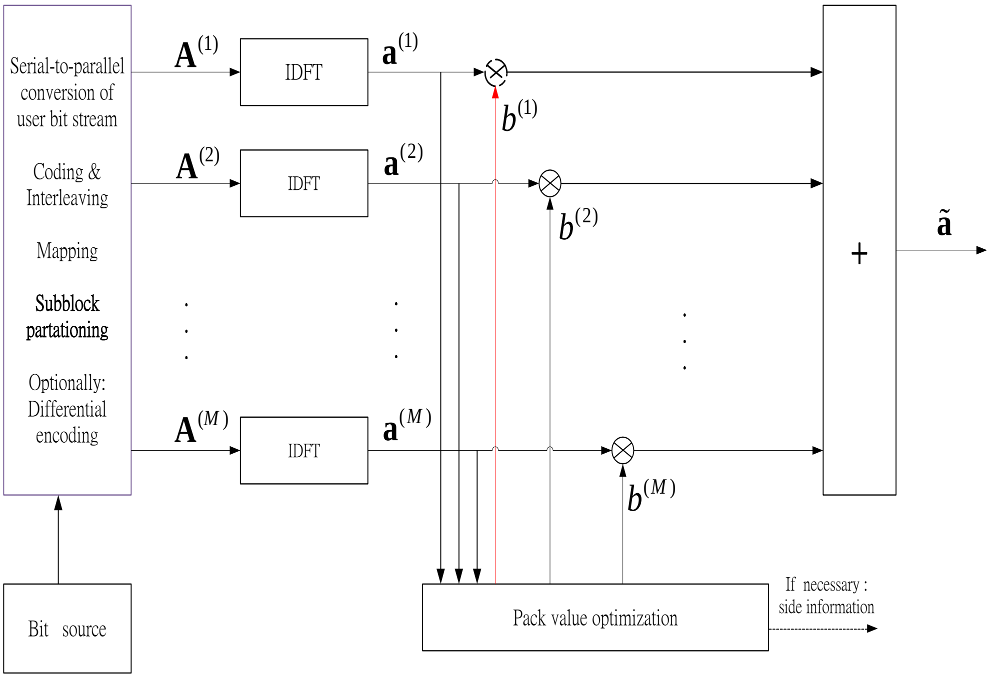

Figure 3 : Partial transmit sequence block diagram

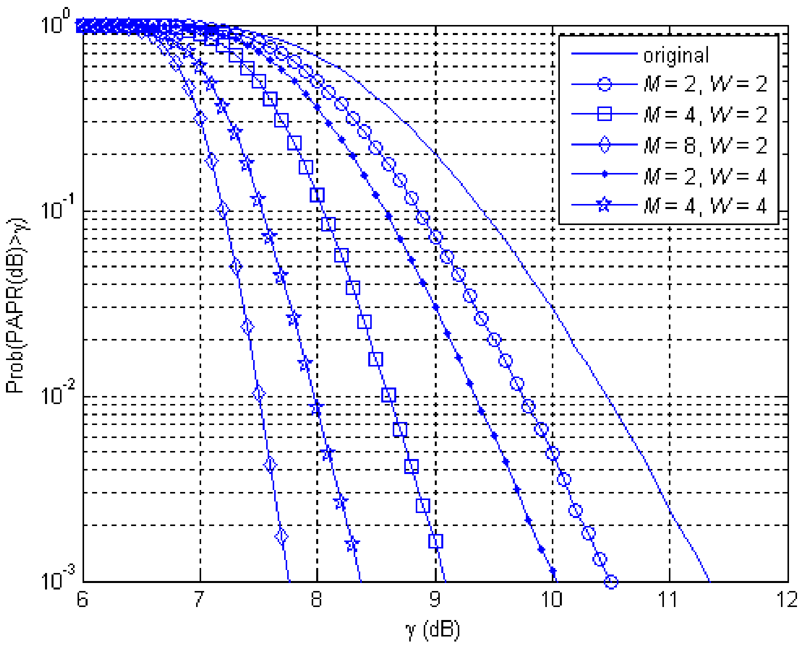

Figure 4 : PAPR reduction using PTS

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In the PTS technique, an input data a block of N symbols is partitioned into disjoint sub-blocks. The subcarriers in each sub-block are weighted by a phase weighting factor for that sub-block. The phase weighting factors are selected such that the PAPR of the combined signal is minimized. For further PAPR reduction, the PTS scheme can be easily combined with the investigated symbol transform scheme. The principle structure of PTS method is shown in Fig. 1 as that in [11]. PTS method is to divide data block into sub-blocks or clusters and then multiply the appropriate phase weighting factors to each sub-blocks to reduce PAPR. We define the data block as a vector $\mathbf{X} = \left[X_1 \quad X_2 \ldots \quad X_N\right]^T$. Then, X is partitioned into *M* disjoint sub-blocks represented by the vector X such that

$$\mathbf{X} = \sum_{i=1}^{M} \mathbf{X}_i$$

III MODIFIED SLM-PTS

3.1 Phase adjustments in PTS: To reduce the amplitude of a high power sample, one straightforward means is to adjust the phases of some chosen sub-blocks to the reverse of the reference phase to keep the phases of the other sub-blocks unchanged.

Thus the amplitude of the composed signal vector in this sample can be substantially reduced

It is found that the phase adjustments of these *M* sub-blocks are not in uniform distribution.

The distribution contains a delta function at zero, corresponding to the probability of maintaining the original phase in a sub-block, and a Gaussian-like distribution with the mean π.

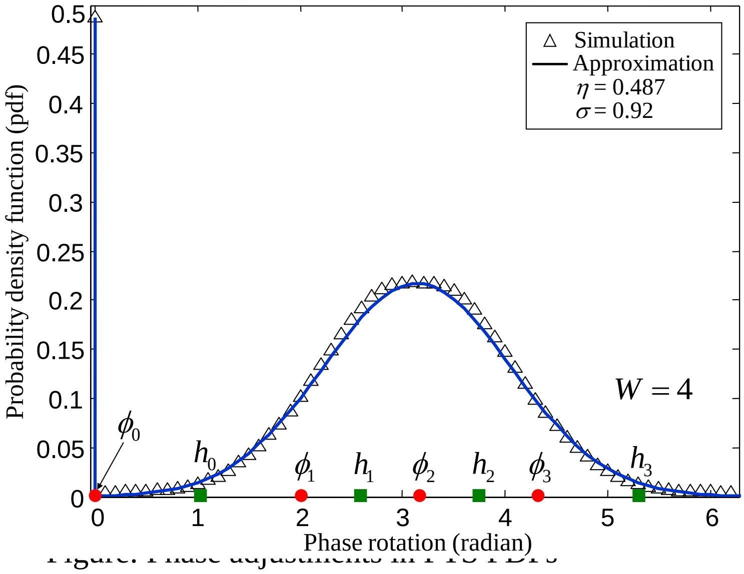

Figure 5 : PDF Vs Phase rotation

3.1 PTS with Non-uniform Phase Set:

For $M = 2$, which leads to two rotational phase factors 1 and -1 being the same as that applied in the conventional PTS However, for $M > 2$ we need to figure out the optimal set of phase factors in the minimum mean square error (MMSE) sense. The distribution of the phase adjustments can be approximated as where η is the probability of maintaining the original phase and σ is the standard deviation that fit in with the Gaussian-like distribution

$$f(\varphi) = \eta\delta(\varphi) + \frac{1-\eta}{\sqrt{2\pi\sigma^2}} \exp\left(-(\varphi-\pi)^2 / 2\sigma^2\right)$$

where η is the probability of maintaining the original phase and σ is the standard deviation that fit in with the Gaussian-like distribution

IV CONCLUSIONS.

Equivalently, the outage probability can be improved by a factor of 10 for a specific PAPR threshold. It must be noted that the optimal set of phase factors can be determined in advance based on system parameters. The required side information is the same as the conventional PTS scheme with uniform phase factors.

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