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A Minimizing-Complexity Hybrid Subblock Segmentation PTS Scheme for PAPR Reduction in MIMO-OFDM System

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Abstract—Multiple input and multiple-output orthogonal frequency division multiplexing（MIMO-OFDM）is used to improve the performance and capacity o the wireless communication system. OFDM is an efficient and promising modulation technique for wireless transmission due to its high spectral efficiency and robustness to frequency selective adding channels. However, it has a high peak to average ratio (PAPR) which is the main disadvantage. Partial transmit sequence (PTS) is one o the most widely used technique that gives a better performance in PAPR reduction or MIMO-OFDM system. However, the computational complexity o the traditional PTS method is tremendous. In this paper, A Low-Complexity Hybrid Subblock Segmentation PTS Scheme or PAPR Reduction in MIMO-OFDM System is proposed. For analytic purposes, we derive computational complexity expressions of the proposed segmentation method and analyze the computational complexity o the proposed segmentation method compared with that o the random segmentation method which has the best Peak to Average Power Ratio (PAPR) reduction performance. The simulation results show that the PAPR reduction performance is degraded only slightly compared with the random segmentation method. *Keywords — MIMO-OFDM, Peak to Average Power Ratio, Partial Transmitted Sequences, Subblock segmentation.*

I. INTRODUCTION

Multiple input multiple output orthogonal frequency division multiplexing (MIMO-OFDM) is one of the most promising techniques for today's wireless communication systems because it is an efficient method of resisting multipath fading channels and improves the bandwidth efficiency. Due to its high spectrum efficiency and the resistance to inter-symbol interference (ISI), MIMO-OFDM has been widely adopted for several applications as high data rate communication systems for numerous wireless applications such as digital audio broadcast, digital video broadcasting, wireless local area networks, wireless metropolitan area networks, etc. Since the MIMO-OFDM system is based on OFDM, One of the major drawbacks associated with MIMO-OFDM systems is that the output signal may have a high PAPR due to a large number of subcarriers. The high PAPR significantly impacts the power efficiency in the transmitter, in detail which causes the reduction of the battery lifetime. Moreover, the time-domain signals with a high PAPR may result in nonlinear distortion in the power amplifier; therefore, how to effectively reduce the higher PAPR of the MIMO-OFDM signals is an important issue. To solve the problem of PAPR, several techniques have been proposed by various researchers such as amplitude clipping [1], coding [2,3], selective mapping (SLM) [4-6]and partial transmit sequence (PTS) [7,8]. These techniques achieve PAPR reduction at the expense of transmit signal power increase, bit error rate increase, data rate loss, computational complexity increase, and so on [9]. The PTS technique is one of the most attractive schemes because of its good PAPR reduction performance and no restrictions on the number of subcarriers; however, the algorithm of the PTS technique still has high computational complexity. The computational complexity reduction of the PTS scheme can be achieved through proper subblock segmentation [10]. Fig. 1illustrates the block diagram of the PTS scheme in MIMO-OFDM. In this paper, the random subblock segmentation and interleaved subblock segmentation methods of PTS are analysed and a low-complexity hybrid subblock segmentation method for PTS is proposed. It is demonstrated that the computational complexity is significantly reduced but the performance is degraded only slightly by using

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the proposed subblock segmentation compared with the random sub-block segmentation.

SYSTEM MODELS

We consider Nt transmit antennas in the MIMO-OFDM system adopted in this paper, over which independent data streams should be communicated without space-time coding, e. g., in[11].

A. PAPR of MIMO-OFDM

The PAPR of output signals at each antenna is defined as the ratio between the maximum peak power and the average power

$$PAPR_{n_t} = 10\log\frac{\max\left\{\left|s_{n_t,k}\right|^2\right\}}{E\left\{\left|s_{n_t,k}\right|^2\right\}}(dB)$$

$$\left(n_t = 1,2,\ldots N_T; k = 0,1,2,\ldots N-1\right) \quad (1)$$

In MIMO-OFDM, the PAPR of all Nt transmit signals should be simultaneously as small as possible, which is defined as

$$PAPR = \max\left\{PAPR_1, PAPR_2, \ldots PAPR_{N_T}\right\} \quad (2)$$

It is known that the CCDF (Complementary Cumulative Distribution Function) is commonly used to denote the probability that the PAPR exceeds a given threshold value z, for conventional OFDM as shown in (3).

$$P\{PAPR > z\} = 1 - \{PAPR \le z\} = 1 - \left(1 - e^{-z}\right)^N \quad (3)$$

In MIMO-OFDM, since the Nt number of antennas, the CCDF is presented

$$P\{PAPR > z\} = 1 - \{PAPR \le z\} = 1 - \left(1 - e^{-z}\right)^{N_T N} \quad (4)$$

It can be seen from (3) and (4) that the PAPR performance of MIMO-OFDM systems is even worse than that of OFDM.

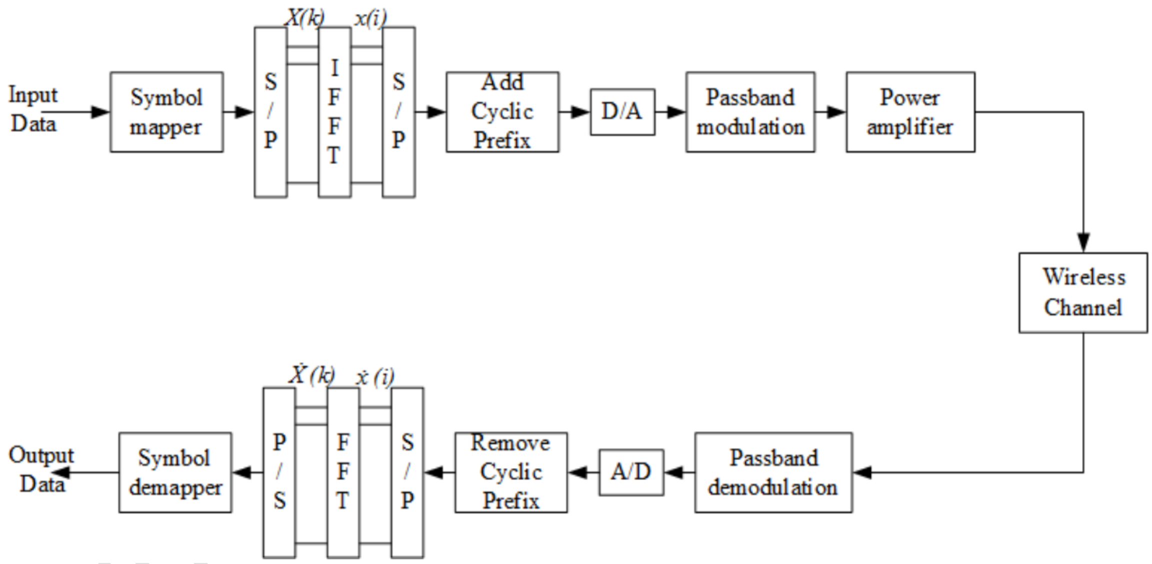

Fig. 1. Block diagram of OFDM model.

B. Partial Transmit Sequence in MIMO-OFDM

The block diagram of the partial transmit sequence (PTS) scheme in MIMO-OFDM is shown in Fig.2. In each antenna channel, it is a single antenna PTS-OFDM. It partitions an input data block of N symbols into M disjoint subblocks as follows:

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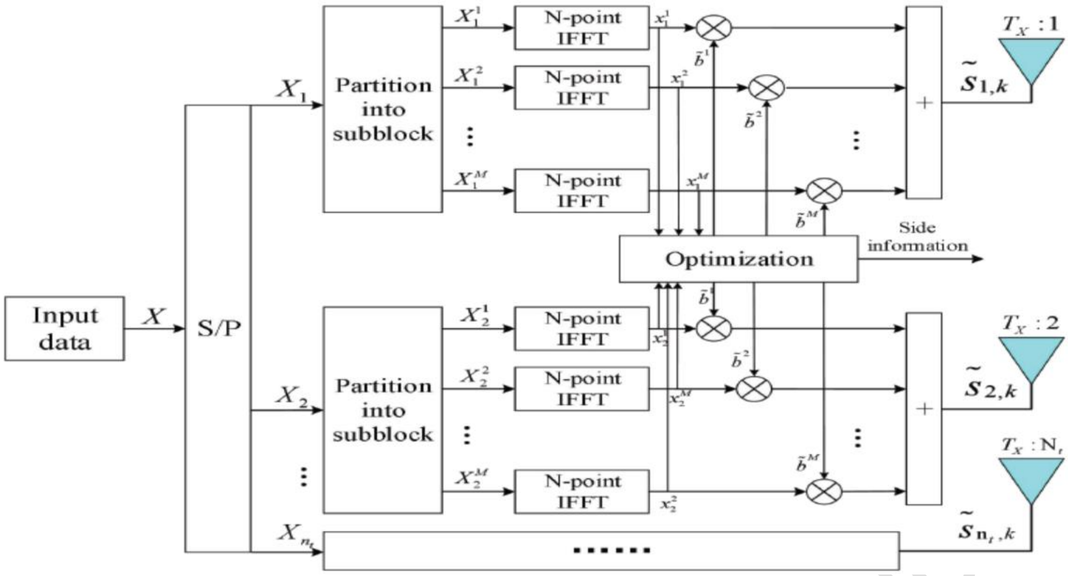

Fig. 2. The block diagram of the PTS scheme in MIMO-OFDM.

Then each partitioned subblock is multiple complex phase factor , 1, 2,..., j b e Mμbe = =μ,sub sequently taking its IFFT to yield

$$x = IFFT\left\{\sum_{\mu=1}^{M} b^{\mu} X^{\mu}\right\} = \sum_{\mu=1}^{M} b^{\mu} x^{\mu} \quad (5)$$

After the PAPR comparisons among the candidate sequences, the optimal phase factor bμ can be got. The corresponding signal in the t antenna with the lowest PAPR can be expressed as

$$\tilde{s}_{n_t,k} = \sum_{\mu=1}^{M} \tilde{b}^{\mu} x^{\mu}, 0 \le k \le N-1, 1 \le n_t \le N_t \quad (6)$$

III. HYBRID PARTIAL TRANSMIT SEQUENCE SCHEME

In the partial transmit sequence scheme, the input data block is partitioned into subblocks. Each subblock is multiplied by a phase factor, which is obtained by the optimization algorithm to minimize the PAPR value. However, the algorithm of the PTS technique has a very high computational complexity. We can choose the appropriate sunblock segmentation method in PTS to reduce the computational complexity. In this section, we will analyze the random segmentation and interleaved segmentation methods of PTS, and a hybrid subblock segmentation method for PTS for reducing the PAPR is proposed. We will also analyze and derive computational complexity expressions for the proposed method.

A. Hybrid Subblock Segmentation Method

In general, random and interleaved subblock segmentation are usually used for the partial transmit sequence scheme. For the random segmentation, every data symbol is assigned to any one of the subblocks randomly. Every data symbol spaced V apart is allocated at the same subblock in the interleaved segmentation. The PAPR performance of random segmentation is the best. However, the computational complexity of interleaved segmentation is lower in two kinds of methods. Random segmentation has the best PAPR performance, but the computational complexity of interleaved segmentation is the lowest of the three kinds of methods. Based on the respective advantages of the three methods, we proposed a new combined segmentation method. We will combine random segmentation and interleaved segmentation so that we can take full advantage of the merit of the two methods to improve the PAPR performance and reduce the computational complexity. In the subblocks, we used random segmentation in the front half subblock and interleaved segmentation in the after half subblock. Fig. 3. shows the example of the hybrid subblock segmentation method.

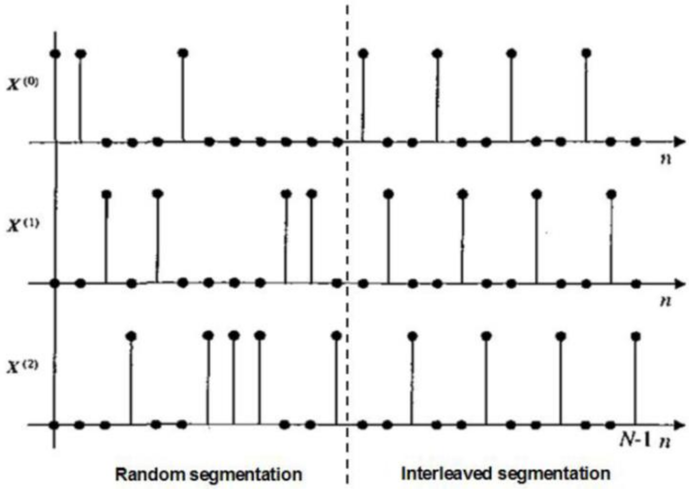

Fig. 3. The example of the combined subblock segmentation method.

IV. SIMULATION RESULTS OF PAPR REDUCTION PERFORMANCE

In this section, some simulations are employed to compare and analyze the PAPR reduction performance and complexity comparison between the proposed scheme and the original PTS scheme. First, we compare the PAPR reduction performance of the random and interleaved segmentation. Then, by applying the proposed method in the MIMO-OFDM system, we evaluate and compare the PAPR reduction performance between the proposed method and the two conventional subblock segmentation methods. Then, we compare the PAPR reduction performance when V is different. The simulation has been performed where the number osubcarriersarrier in an OFDM symbol of each antenna channel and subblocks are set to 128 an,d 2, 4 or 8. We use the QPSK modulation as the signal mapper for the MIMO-OFDM systethe m and phase factor is ( ) { } −∈ 1,1 v b. For simplicity, we expect all N subcarriers to be active. Fig. 3 shows the PAPR reduction performance for the proposed segmentation relative to the random and interleaved segmentation when V=4.

TableI. The parameter used for the simulation of paper

Simulation parameters	Type/Values
Number of random OFDM block	10000
Number of subcarriers(N)	128
Number of subblocks(V)	2/4/8
Antenna number(N_t)	2
Modulation scheme	QPSK
Phase weighting factor(b)	1,-1

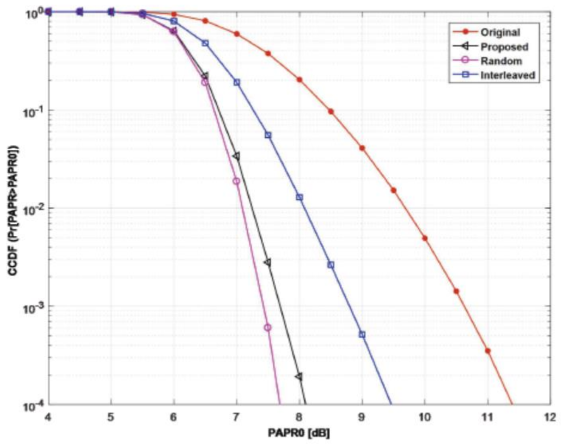

Fig. 3. The PAPR reduction performance for the hybrid segmentation relative to the random and interleaved segmentation when V=4.

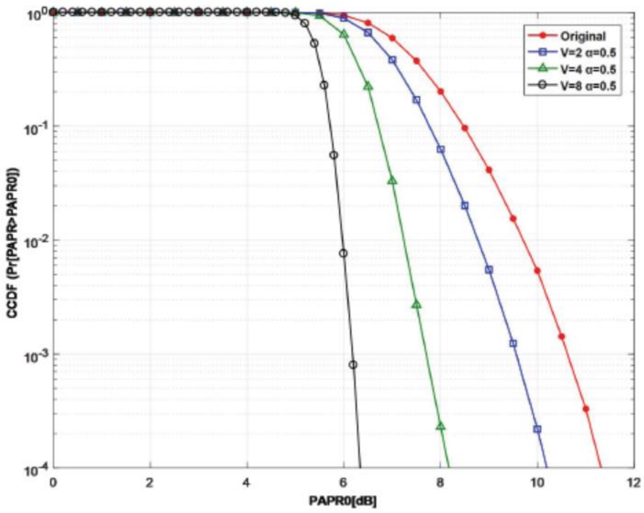

Fig. 4. The PAPR reduction performance of new segmentation in different subblock

When N = 128, V = 4, compared with the random segmentation which has the best PAPR reduction performance, there is only a small difference of 0.5[dB] when the $CCDF$ = 10-4. However, the reduced calculation amount of complex multiplications is 40.2%, complex additions are 61.6%, the PAPR reduction performance of the proposed segmentation method is similar to random method. Fig. 4 shows the PAPR reduction performance of the hybrid segmentation method in different subblocks when N = 128, V =2，4，8. It can be observed that the number of subblocks is larger, the computational complexity is larger, and the PAPR reduction performance is better because the computational complexity is larger. The number of subblocks can be chosen as large as possible for communication systems in which high PAPR reduction performance is required.

V. CONCLUSIONS

In this paper, we proposed a hybrid subblock segmentation method. The PAPR reduction performance of the proposed subblock segmentation in the MIMO-OFDM system was close to that of the random segmentation method which had the best PAPR reduction performance. we also derived a computational complexity expression for the proposed method. Compared to the conventional random segmentation, the proposed method showed almost the same PAPR reduction performance. However, the hybrid subblock segmentation method reduced computational complexity significantly. When N=128 and V=4, the reduction of the amount of complex is 41.1%. The new hybrid subblock segmentation method can be useful for the PAPR reduction in MIMO-OFDM system applications. Theoretical

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analysis and simulation results demonstrate that the proposed scheme outperforms the conventional PTS scheme in the PAPR reduction performance and computational complexity.

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