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Peak-to-Average Power Ratio Reduction (PAPR) of OFDM Signals Using Space Frequency Block Code (SFBC) Based Partial Transmit Sequence (PTS) in MIMO Systems

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Abstract: *In this paper, the partial transmit sequences scheme for the Peak-to-Average Power Ratio (PAPR) reduction in Multi-Input Multi-Output Orthogonal Frequency Division Multiplexing (MIMO-OFDM) system with Space Frequency Block Coding (SFBC) is proposed. The key idea of the paper is to generate some multi-sequences via combining the signals at different transmit antennas in SFBC structure. Theoretical analysis and simulation results validate that the proposed scheme has the ability to provide large PAPR reduction with low bit error rate and low computational complexity without side information to the receiver in SFBC MIMO-OFDM systems.*

Keywords: *Multi-Input Multi-Output Orthogonal Frequency Division Multiplexing (OFDM), Space Frequency Block Code (SFBC), Partial Transmit Sequence (PTS), Peak-to-Average Power Ratio (PAPR)*

1. Introduction

The elementary knowledge of multicarrier modulation is to divide the transmitted bitstream into many distinctive substreamsand send these across many different subchannels. Characteristically the subchannels are orthogonal underideal propagation conditions, in which the multicarrier modulation is often referredto as Orthogonal Frequency Division Multiplexing (OFDM). The data rate on each of the subchannels and the corresponding sub channel bandwidth will be lesser than the total data rate, and the total system bandwidth respectively [1]. The number of substreams chosen to insure that the bandwidth of each sub channel is lesserthan the coherence bandwidth of the channel, so that the subchannels under go relative flat fading.Thus,the Inter Symbol Interference [ISI] on each subchannel is insignificant. Moreover, in the discrete implementation of OFDM, often called Discrete MultiTone (DMT), the ISI can be completely removed through the use of a cyclicprefix. The subchannels in OFDM need not be closest, so a large continuous block of spectrum is not needed for high rate multicarrier communications. Recently, various algorithms of the PAPR reduction have been proposed for Single-Input Single-Output (SISO) OFDM systems in the literature, including clipping, nonlinear commanding transform, coding technique, Selected Mapping (SLM), go lay sequence and the weighting factor estimation Method [2].However, when these methods are employed directly to reduce the PAPR in MIMO-OFDM systems, it results in the increasing of the intricacy and redundancy with the increasing number of antennas [3]. Henceforth, the several new schemes namely, Poly-Phase Interleaving and Inversion (PII) have been proposedspecially for MIMO-OFDM systems.The best advantage of both the PTS/SLM and PII schemes is providing a good PAPR reduction without signal distortion. However, the computational complexity of the PTS/SLM and PII schemes is very high, as they need to implement additional Inverse Discrete Fourier Transform (IDFT) operations and iterations of phase optimization. Apparently, the computational complexity of the scheme proposed is reduced, at the cost of PAPR reduction. Moreover, its optimal phase rotation vectors also need to be transmitted as side information to the receiver, resulting in loss of the data rate.In this paper, Partial Transmit Sequences (PTS) scheme is proposed to reduce the PAPR of MIMO-OFDM signals. For accessibility and simplicity, the Space Frequency Block Coding (SFBC) is employed in MIMO-OFDM systems. For the proposed PTS method, original data sequences at two antennas are segregated into several pairs of subblocks, and each pair of subblocks multiplies by different factors to generate different pair of subblocks. Then, the obtained new subblocks are combined to generate PTS, with the structure and the diversity capability of the SFBC. Finally, the pair of alternative sequences with the smallest PAPR is chosen to be transmitted. Obviously, the factors of the selected pair of sequences have to be transmitted as side information.However, if the factors are chosen particularly, the transformed pair of the constellation points corresponds to only one pair of original constellationpoints. As a result, the received pair of the constellation points could determine its corresponding original data without side information at the receiver. The results of the Simulation show that the PTS scheme with good PAPR reduction, and the SFBC-PTS method without side information could provide the same Bit Error Rate (BER) performance as that of the PTS scheme with perfect side information in SFBC MIMO-OFDM with 4-QAM and 16-QAM, respectively.

2. MIMO-OFDM SYSTEM

MIMO uses multiple transceivers at both the transmitter and receiver to operate. Because MIMO allows more bits/sec/hertz to be transmitted in a given bandwidth, it improves spectral efficiency and allows operators to simultaneously support more users with high data-rate requirements. Increased spectral efficiency, higher data rates and the ability to increase data throughput without additional bandwidth or transmit power, makes MIMO especially attractive for use in wireless communication systems.In MIMO terminology, the "Input" and "Output" are referenced to the wireless channel, which includes the antennas. Performance gains are achieved as multiple transmitters simultaneously input their signal into the wireless channel and then combinations of these signals simultaneously output from the wireless channel into multiple receivers. For downlink communication, a single Base Station (BS) would contain multiple transmitters connected to multiple antennas and a single Mobile Station (MS) would contain multiple antennas connected to multiple receivers[5].Each subcarrier carries one bit of information out of total N bits by its existence or nonexistence in the output frequency band. The known frequency at the receiver of each subcarrier is selected to produce an orthogonal signal set. At a periodic interval T,the output is timely upgraded with the symbol period as well as the time boundary for orthogonality. Figure 4 shows the resultant frequency spectrum. In the frequency domain, the resulting sin function side lobes produce overlapping spectra. The individual peaks of subbands all line up with the zero crossings of the other subbands [10]. The overlapping of spectral energy does not interfere with the system’s ability in recovering the original signal. The receiver multiplies (i.e., correlates) the incoming signal by the known set of sinusoids to produce the original set of bits sent. The digital implementation of an OFDM system will enhance these simple principles and permit more complex modulation.

3. PAPR REDUCTION TECHNIQUES

The high Peak-to-Average Power Ratio (PAPR) or Peak-to-Average Ratio (PAR) or Crest Factor of the Orthogonal Frequency Division Multiplexing (OFDM) systems can be reduced by using various PAPR reduction [4] techniques namely:-**Multiple Signal Representation Techniques**

1. Partial Transmit Sequence(PTS)
2. Selective Mapping(SLM)

4. SELECTIVE MAPPING METHOD

The CCDF of the original signal sequence PAPR above threshold PAPR0 is written as Pr {PAPR >PAPR0}. Thus for K statistical independent signal waveforms, CCDF can be written asPr {PAPR >PAPR0}, so the probability of PAPR exceed the same threshold [6]. The probability of PAPR larger than a threshold Z can be written as in equation (1)

$$P\,(PAPR<Z) = F\,(Z)\,N = 1-(\exp\,(-Z))\,N \quad (1)$$

Assuming that M-OFDM symbols transmit the same valid information,which are statistically independent of each other. Here, the probability of PAPR is greater than Z and is equal to the product of each independent probability. This process can be written as in equation (2)

$$P\,(PAPRlow<Z) = (P\,(PAPR>Z)\,M = 1-(\exp\,(-Z)\,N)\,M \quad (2)$$

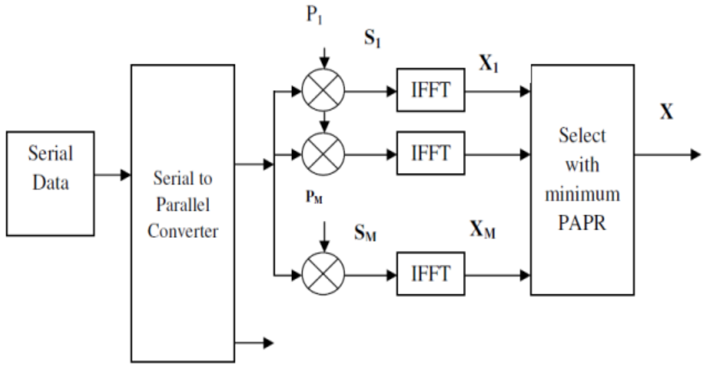

Fig 1. *Block Diagram of Selected Mapping Technique [6]*

In selection mapping method (fig 1), Initially M statistically independent sequences are generated, to represent the same information and next, the remaining M statistically independent data blocks Sm=[Sm,o;Sm,1;Sm,2…..Sm.n-1],for m=1, 2,...,M are then forwarded into IFFT operationXm=[x1,x2,x3…..xn]Tin discrete time-domain are acquired and then the PAPR of these M vectors are assessed individually. Eventually, the sequences xd with the smallest PAPR is selected for final serial transmission.

5. Partial Transmit Sequence (PTS)

Partial Transmit Sequence (PTS) algorithm is a technique for improving the statistics of a multicarrier signal [7]. The basic ideas of partial transmit sequences algorithm is to divide the original OFDM sequence into several sub-sequences and for each sub-sequences multiplied by different weights until an optimum value is chosen (fig 2)

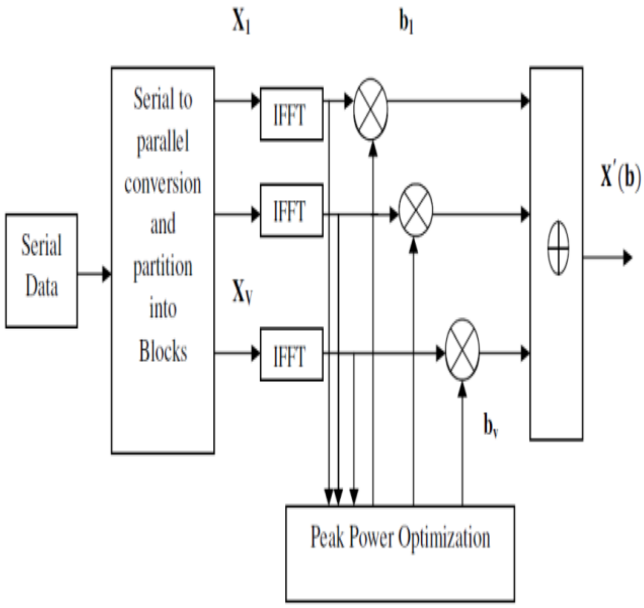

Fig 2. *Block Diagram of Partial Transmit Sequence Technique [7]*

From the left side of diagram, the data information in frequency domain X is separated into V non-overlapping sub-blocks of sizeN [11, that each N/V nonzero elements and set the rest part to zero. These sub-blocks are assumed to have the same size and no gap between each other. The sub-block vector is given by equation (3)

X=∑v=1 to V bvXv-(3)

In this method, input data block X is partitioned in M disjoint sub blocks. Xm= [Xm, 0; Xm, 1; Xm,2...... Xm, N-1] T; m=0, 1, 2...M-1; such that ∑m-1 to M Xm=X and sub blocks are combined to minimize PAPR in time domain. Here S times Over sampled time domain signal of Xm (m=0, 1, 2....m-1); is obtained by taking the IDFT length of NS on Xm concatenated with (S-1) N

Zeros.Complex Factor bm=∑∑¢jǿm,(m=0,1,2...M-1) are introduced to combine PTS. The set of Phase factors is denoted as vector b= [b0.b1.....bM-1] T.

6. SFBC USING PARTIAL TRANSMIT SEQUENCE

The most well-known transmit diversity technique was introduced by SFBC where the proposed orthogonal code ensures full diversity As shown in , the Block code pre-coding can be implemented either as a SFBC or as a Space- Frequency Block Code (SFBC). In order to simplify the descriptions of our proposed method, we consider a SFBC System with two transmits and one receivesantennas [8]. For other systems with more transmit antennas, our proposed method can be easily extended fig (3)

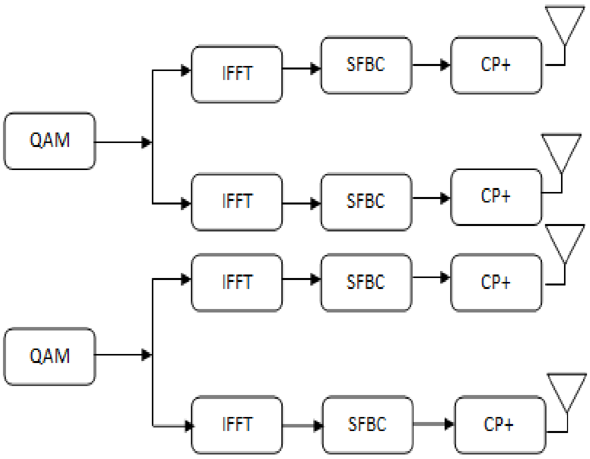

Fig 3. *Basic SFBC MIMO-OFDM Systems [8]*

7. PRINCIPLE OF OUR PROPOSED TECHNIQUE

Our proposed technique follows these steps:

1) Multiply the original data X by independent phase Sequences and obtain X_,

2) Each couple (X_ 2k, X_ 2k+1) will be encoded according to the pre-coder codebook M; the resulted sequence with the lowest PAPR will be kept and transmitted.

Basically, this method uses a predefined set E of possible phases. This set E consists of two subsets: E1 leaves unchanged the OFDM signal constellation whereas E2 is the set of its rotated constellation with a specific _opt angle. If the constellation points (in set E) are very close, the rate of errors detection phase will be increased [9]. That is why we propose to calculate a minimum distance, dmin, separating two different types of constellation (E1 and E2): the selected one _opt is the one having the biggest dmin. We illustrate in Table I the corresponding _opt for 4, 16 and 64 QAM.Denote all possible combinations of the factors where denotes the number of choices for the factor combinations. At the receiver is obtained after decoding of the SFBC. Then, a hard decision is made to each elements of X with the minimum distance of the constellation used at the transmitter, and the sequence X = {= 0, 1,….., − 1} without channel noise is obtained.

$$
\begin{cases}
\begin{cases} Z^m_{v,2l} = \bar{\bar{X}}_{2l}, \\ Z^m_{v,2l+1} = \bar{\bar{X}}_{2l+1}, \end{cases} & v = 0, \\
\begin{cases} Z^m_{v,2l} = \frac{a_v \bar{X}_{2l} - b_v \bar{X}_{2l+1}}{a_v^2 + b_v^2}, \\ Z^m_{v,2l+1} = \frac{b_v \bar{X}_{2l} + a_v \bar{X}_{2l+1}}{a_v^2 + b_v^2}, \end{cases} & 1 \le v \le \frac{V}{2}, \\
\begin{cases} Z^m_{v,2l} = \frac{a_v \bar{X}^*_{2l} - b_v \bar{X}_{2l+1}}{a_v^2 + b_v^2}, \\ Z^m_{v,2l+1} = \frac{b_v \bar{X}_{2l} + a_v \bar{X}^*_{2l+1}}{a_v^2 + b_v^2}, \end{cases} & \frac{V}{2} + 1 \le v \le V.
\end{cases}
$$

Then, the sequence X is divided into M subblocks for each subblock, we could obtain (□+ 1)partial transmit sequences

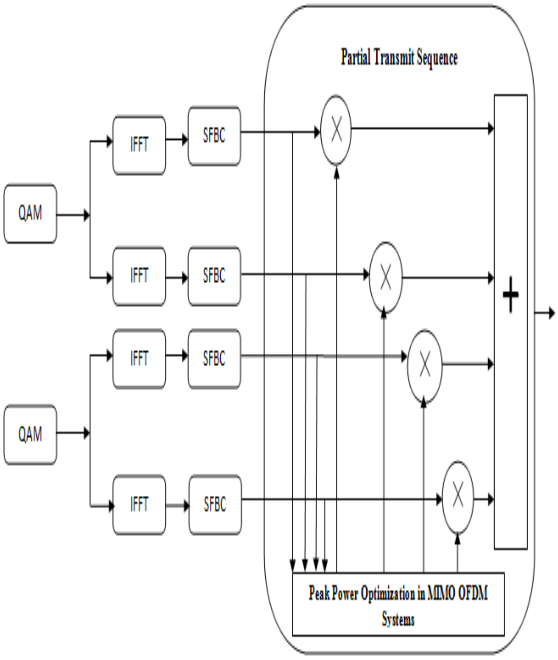

Fig 4. *SFBC Using PTS in MIMO-OFDM System*

8. Result Analysis

To reduce the computational complexity of a PTS-based OFDM system, most authors focus on reducing the number of candidate signals.

	K=256	K=128	K=64
Original PAPR	11.85db	11.53db	11.22db
SLM N=4	9.75db	9.52db	9.32db
SLM N=6	9.12db	8.21db	8.01db
Original PAPR	10.95db	10.75db	10.25db
PTS V=4	9.12db	8.42db	8.12db
PTS V=6	7.56db	7.21db	6.65db
Without SFBC Using PTS	above 8db	above 8db	above 8db
With SFBC Using PTS	6.25db	5.28db	4.95db

Therefore, the computational complexity is reduced clearly at the cost of performance loss for PAPR reduction. Unlike these methods, the proposed scheme reduces complexity by using the correlation among the adjacent candidates. Since the number of candidate signals is not reduced, it can achieve the same PAPR reduction as the conventional PTS scheme.

9. Conclusions

In this paper, an efficient PAPR reduction technique dedicated to MIMO-OFDM systems using SFBC codebook is focused and induces an embedded signaling through the advanced pre-coders codebook that leads to a powerful recovery of the transmitted signal and guarantees a very low failure decision rate. To further improve the decision process, we proposed an additional embedded signal that consists of a set of rotated and un-rotated QAM constellations and whenUsed in the decision process (using a hard decision deduced from a Max-Log-MAP decoding), it significantly improves the MIMO-OFDM system performances in terms of CCDF of the PAPR, SIER and BER. This decision criterion ensures a good decision performance when the absolute LLR value is greater than a certain threshold. But when it is close to zero (for very low SNR values), the decision can be biased. To overcome this issue, conceiving a soft decision process would be an appropriate solution: this is a research aspect that we are currently investigating.

REFERENCES

[1] L.J.Cimini, Jr, "Analysis and Simulation of a Digital Mobile Channel using OFDM", IEEETrans. On Communications, vol.Com-33, no.7, pp.665-675, July 1985.

[2] R.V.Paiement, "Evaluation of Single Carrier and Multicarrier Modulation Techniques for Digital ATV Terrestrial Broadcasting CRC Rep", Ottawa, ON, Canada, CRC-RP-004, 1994.

[3] T.de.Couasnon, et al, "OFDM for Digital TV Broadcasting", Signal Processing, vol.39, pp.1-32, 1994.

[4] X. Li and L. J. Cimini, Jr., "Effects of clipping and filtering on the performance of OFDM," IEEE Commun.Lett., vol. 2, no. 5, pp. 131–133, May 1998.

[5] X. B.Wang, T. T. Tjhung, and C. S. Ng, "Reduction of peak-to-average power ratio of OFDM system using a companding technique," IEEETrans. Broadcast, vol. 45, no. 3, pp. 303–307, Sep. 1999.

[6] C. P. Li, S. H. Wang, and C. L. Wang, "Novel low-complexity SLM schemes for PAPR reduction in OFDM systems," IEEE Trans. SignalProcess.vol. 58, no. 5, pp. 2916–2921, May 2010.

[7] S. H. Muller and J. B. Huber, "OFDM with reduced peak-to-average power ratio by optimum combination of partial transmit sequences," Electron. Lett., vol. 33, no. 5, pp. 368–369, Feb. 1997.

[8] A. E. Jones, T. A. Wilkinson, and S. K. Barton, "Block coding scheme for reduction of peak to mean envelope power ratio of multicarrier transmission scheme," Electron.Lett., vol. 30, no. 25, pp. 2098-2099, Dec. 1994.

[9] Tao Jiang, Member IEEE, and Yiyan Wu, Fellow, IEEE, "An Overview: Peak-to-Average Power Ratio Reduction Techniques for OFDM Signals" VOL. 54, NO. 2, 2008

[10] R. Prasad, OFDM for Wireless Communications System. Artech House, Inc., 2004.

[11] Jayalath, A.D.S, Tellainbura, C, "Side Information in PAR Reduced PTS-OFDM Signals," Proceedings 14th IEEE Conference on Personal, Indoor and Mobile Radio Communications, Sept. 2003, vol. 1, PP. 226-230.