PAPR Reduction by using Cooperative PTS for SFBC MIMO-OFDM Systems

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Abstract— Multiple input multiple output (MIMO) orthogonal frequency division multiplexing (OFDM) system has been receiving a great attention for high-data-rate transmission. MIMO can be used to improve the performance and increase the capacity of wireless communication systems. OFDM is a popular technology and has been adopted for many new and emerging broadband communication systems including wireless LAN, WIMAX, Digital Video broadcasting and 4G mobile systems. MIMO-OFDM suffers from high PAPR, this demands expensive linear amplifiers with wide dynamic range. In MIMO-OFDM systems, a straightforward way for PAPR reduction is to apply existing techniques separately on each transmit antenna, then the overall PAPR reduction is obtained. For orthogonal frequency division multiplexing (OFDM) system, several Peak-to-average power ratio (PAPR) reduction schemes have been presented in recent years. The conventional partial transmit sequences (PTS) scheme can be applied to each transmitting antenna directly to reduce the PAPR of MIMO-OFDM systems, but it has high computational complexity. To better handle dispersive channel, Space frequency block code (SFBC) MIMO-OFDM is preferred. SFBC is a coding technique used for transmission diversity. In this the antennas are separated by space and subcarriers are separated by frequency and the coding is performed in a block.

Key words: MIMO, OFDM, PAPR, WIMAX, SFBC, MIMO-OFDM

I. Introduction

OFDM is a popular technology and has been adopted for many new and emerging broadband communication systems including wireless LAN, WIMAX, Digital Video broadcasting and 4G mobile systems. In these techniques, the transmission frequency band is divided into a large number of subcarriers that are orthogonal to each other. The information is then divided onto multiple lower speed signals that are transmitted simultaneously on different frequency in parallel. MIMO is the use of multiple antennas at both the transmitter and receiver to improve communication performance. OFOM combined with MIMO technology is an attractive candidate for modern mobile communication systems due to its ability to support high data rates, large capacity, and robustness to multipath fading. Recently, Multiple input multiple output (MIMO) orthogonal frequency division multiplexing (OFDM) with space frequency block code (SFBC) has attracted increasing attention because it is robust to time selective fading channels. However, SFBC MIMO-OFDM signal also inherit disadvantages from OFDM techniques e.g. sensitivity to synchronization errors and high peak-to-average power ratio (PAPR).Therefore many PAPR reduction methods have been introduced. Especially, the signal scrambling methods such as partial transmit sequence (PTS), selective mapping, polyphase interleaving and inversion, cross-antenna translation and partial shift sequence method. All the PAPR reductions methods have some drawbacks like increase in transmit power, high bit error rate (BER), high computational complexity, reduction in bit transmission rate of the system and high peak-to-average power ratio. In this paper, a co- operative partial transmit sequence (Co-PTS) is proposed for SFBC MIMO-OFDM. In Co-PTS, alternate optimization and spatial sub block circular permutation are combined the use of alternate optimization results improvement in performance for PAPR reduction.

II. Existing Method

In the past few years, many researchers have been working on the reduction of peak-to-average power in MIMO-OFDM systems using the different techniques. Some of the existing techniques are clipping, selective mapping, poly phase interleaving, partial transmit sequence etc. However, these techniques have some drawbacks like increase in transmit power, high bit error rate (BER), high computational complexity, reduction in bit transmission rate of the system. A straightforward way for PAPR reduction is to apply existing techniques separately on each transmit antenna, then the overall PAPR reduction is obtained.

There are many methods for reduction of peak-to-average power (PAPR). Reduction of PAPR is a significant factor in MIMO-OFDM systems. It includes the measurement of peak power, rms power, average power, bit error rate, data transmission rate. The methods for PAPR reduction can be classified into two categories with respect to the computational operation applied on the signals.

A. *Clipping*

Clipping is one of the techniques to reduce PAPR. In this technique the peak amplitude is reduced which in turn reduces the peak power and hence the overall PAPR can be reduced. Clipping is of two types: positive clipping and negative clipping. In positive clipping the positive peak amplitude is reduced and in negative clipping the negative peak amplitude is reduced. This technique has several disadvantages:

1) The performance of BER could be affected negatively due to the in-band distortion caused by clipping.
2) Also out-of-band radiation usually appears with clipping technique that could disturb the adjacent channels.

B. *Selective Mapping*

Selective mapping is a distortion less technique that can reduce PAPR efficiently without increase in power requirement and data rate loss. In this technique different signals are generated to represent same information and the signal with less PAPR is transmitted. The main disadvantage of this technique is sending the extra side information index along with the transmitted OFDM system. In this technique, the transmitter generates a sufficiently large number of alternative OFDM signal sequences, all representing the same information as the original symbol. Then each of these alternative input data sequences is made the IDFT operation and the one with the lowest PAPR is selected for transmission. Each input data symbol S is multiplied by U different phase sequences, each of length N, B (u) = b {(u; 0); _ _ _;b (u; N-1)}; u = {0; _ _ _; U -1}, resulting in U modified data symbol. After applying SLM to S. The original SLM scheme has the next characteristics:

- Information about the selected phase sequence should be transmitted to the receiver aside information. At the receiver, the reverse operation is performed to recover the original data symbol. However, an SLM algorithm without explicit side information is proposed.
- For implementation, the SLM technique requires a bank of UIDFT operations to generate a set of candidate transmission signals, and this requirement usually results in high computational complexity.
- There are some approaches attempting to decrease the complexity like.
- This approach is applicable with all types of modulation and any number of subcarriers.
- The amount of PAPR reduction for SLM depends on the number of phase sequences U and the design of the phase sequences.

C. Conventional Partial Transmit Sequence

In the conventional PTS scheme, the input data block is partitioned evenly into disjointed subblocks. The inverse fast Fourier transform (IFFT) outputs of the sub blocks are weighted by a set of rotation factors and then added to form various candidate signals, where the signal with the lowest PAPR value is transmitted. The conventionality scheme is a non-distortion technique and has a good PAPR reduction performance, but it also has high computational complexity and needs to send side information to the receiver.

D. Coding Technique

Coding techniques consist in selecting the code words that minimize or reduce the PAPR. Initially the idea was introduced .This scheme requires exhaustive computational load to search the best code words and to store the large lookup tables for encoding and decoding, especially with large number of subcarriers. Moreover, these techniques do not address the error correction and, moreover, to deal with the error correction it uses an additive offset. It enjoys the twin benefits of power control and error correction, but requires extensive calculation to find good codes and offset. Also there are approaches in which the use of SPACE FREQUENCY BLOCK CODING (SFBC) was proposed to reduce the PAPR without the restriction of the frame size. In Reed-Solomon (RS) codes over the Galois field are employed to create a number of candidates, from which the best are selected. Considering the characteristics of those coding techniques, the main disadvantage of those coding methods is the good performance at the cost of coding rate, and a high computational load to each the adequate code words.

E. Constellation Extension

In Constellation Extension techniques the key is to play intelligently with the outer constellation points that are moved within the proper quarter-plane as such that the PAPR is minimized. The minimum distance of the constellation points is not affected and it consequently guarantees no BER degradation. These methods do not require the transmission of side information to the receiver. There is no data rate loss. Nevertheless, constellation expansion schemes introduce an increase in the energy per symbol. In Active Constellation Extension (ACE) is presented, and in this method all symbols are expanded but its computational burden is high. More recent, a metric-based symbol predistortion scheme has been introduced in. In this method, a metric, defined mathematically in is used to measure how much each frequency domain symbol contributes to large peaks, and the frequency-domain symbols with the highest metric values are selected and predistorted with a constant scaling factor.

III. PROPOSED METHOD

The proposed algorithm converts the serial input data into parallel data. Inverse Fast Fourier Transform (IFFT) is applied to each symbol and then to increase the number of candidate sequence, spatial sub block circular permutation is used for the same odd sub block across all the transmitting antennas. After the spatial sub block circular permutation being performed once, one of the odd sub blocks at each antenna is transformed. So, it can make use of the entire weighted even sub blocks once more to increase the number of candidate's sequence. Then, a candidate sequence with the lowest PAPR at each transmitting antenna can be obtained, and all the candidates sequence finally all the antennas make up a set of candidate sequence. Finally, after all of the spatial sub block circular permutations are completed, now the optimal set of a candidate sequence across all the antennas is for transmitting.

A. PAPR Calculation

The level of amplitude fluctuation of OFDM signals is usually measured in terms of the ratio of the peak power to the average envelope power of the signal. More specifically, PAPR should be defined over s (t), which is the actual input to the HPA, rather than over x (t), therefore, the pass band continuous time PAPR can be defined as

$$\mathbf{PAPR(s(t))} = \frac{\max_{0\leq t\leq NT} |{|s(t)|^2}|}{IE[|s(t)|^2]} \quad ......(3.1)$$

Where IE [.] and max [.] denotes the mathematical expectation and the maximum value, respectively. However, since this approach would lead to some mathematical complications, it is a common practice to measure the baseband continuous time PAPR, which can be defined as

$$\mathbf{PAPR(x(t))} = \frac{\max_{0\leq t\leq NT} [|x(t)|^2]}{IE[|x(t)|^2]} \quad ......(3.2)$$

As long as fc >> 1/NT, x (t) has the same peak power of s(t), a condition that is always met in all practical systems , but the average power of x(t) is half the average power of s(t).Thus, the PAPR(s (t)) is generally larger than PAPR(x (t)) by 3dB. The maximum of |x (t) |2can be computed by setting its derivative to zero. Unfortunately, this operation is not trivial, since the derivative is a sinusoidal function and its roots cannot easily be found. To overcome this difficulty, it is expedient to define the baseband discrete time PAPR as

$$\mathbf{PAPR}(\mathbf{x}(\mathbf{n})) = \frac{\max_{0\leq t\leq NT} [|x(n)|^2]}{E[|x(n)|^2]} \quad \text{.............................(3.3)}$$

The output signal of the IFFT x (n) is transformed to x (t), by a LPF called digital to analogue converter (DAC), where the peak power can be increased while maintaining a constant average power. Usually, the PAPR of x (t) is larger than that of x (n) by 0.5~1.0 dB [4], the relationship between PAPRs is given as

$$\mathbf{PAPR}(\mathbf{x}(\mathbf{n})) \leq \mathbf{PAPR}(\mathbf{x}(\mathbf{t})) < \boldsymbol{PAPR}(\mathbf{s}(\mathbf{t})) \quad \text{............(3.4)}$$

Practically, PAPR(x (t)) can be measured only after implementing the actual hardware, including DAC. For that reason, there must be some means of estimating PAPR(x (t)) from x (n). Oversampling is used to calculate the actual value of x (t), by zero padding of x (n) and increasing the size of the IFFT used. An oversampling rate L=4 is sufficient to approximate the continuous time signal.

IV. Design SFBC MIMO-OFDM System

Space frequency block coding is used since it has many advantages compared to other systems. The block diagram consists of serial to parallel converter and so on. Similar to BPSK, QPSK is used in various cellular wireless standards such as GSM, CDMA, LTE, 802.11 WLAN, 802.16 fixed and mobile WiMAX, Satellite and CABLE TV applications. As difference between any two constellation point is 90 degree maximum, QPSK modulation type has many benefits. where k and n are the frequency and time indices respectively. For the convenience, we omit the use of superscript in the sequel.

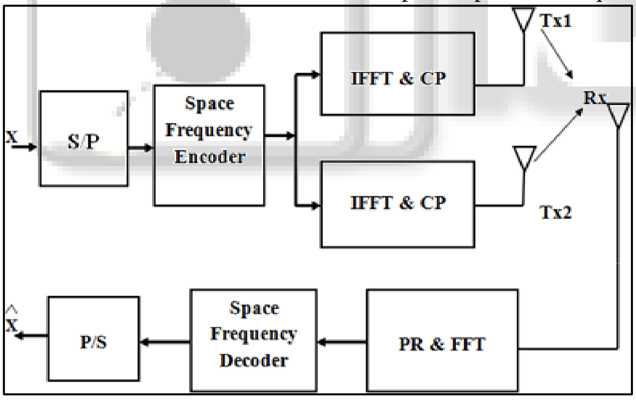

Fig. 1: Block Diagram of SFBC MIMO-OFDM System Cooperative PTS

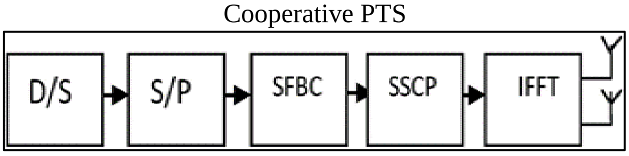

Fig. 2: Co-PTS with SFBC MIMO-OFDM

A Co-operative partial transmit sequence (Co-PTS) is based on alternate partial transmit sequence (a-PTS). In Co-PTS, to increase the number of candidate sequence, spatial sub block circular permutation is used for the same odd sub block across all the transmitting antennas. After the spatial sub block circular permutation being performed once, one of the odd sub blocks at each antenna is transformed. So, it can make use of the entire weighted even sub blocks once more to increase the number of candidate's sequence. Then, a candidate sequence with the lowest PAPR at each transmitting antenna can be obtained, and all the candidates sequence finally all the antennas make up a set of candidate sequence. Finally, after all of the spatial sub block circular permutations are completed, now the optimal set of a candidate sequence across all the antennas are for transmitting.

The proposed design is shown in Figure 3.Firstly the input sequence is modulated by QPSK modulation and converting into parallel form. The modulated signal X is coded into two vectors X1(n) and X2(n) by space frequency encoder block and a factor spatial sub-block circular permutation (SSCP) is introduced to achieve the modulate PAPR reduction performance Then, all SSCP data block are transformed into time domain to get transmitted symbol or simply take IFFT of that sequence. Finally, the one signal with the minimum PAPR is selected for transmission.

V. Simulation Results

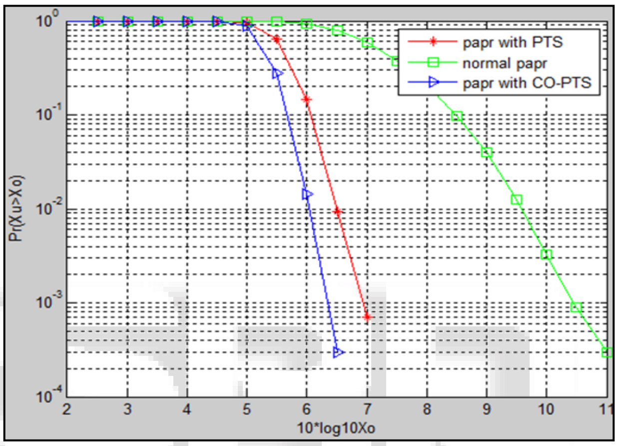

Fig 6.1 PAPR performance of SFBC MIMO-OFDM signal in case 128subcarriers, 4 sub block and phase weighting factor ±j

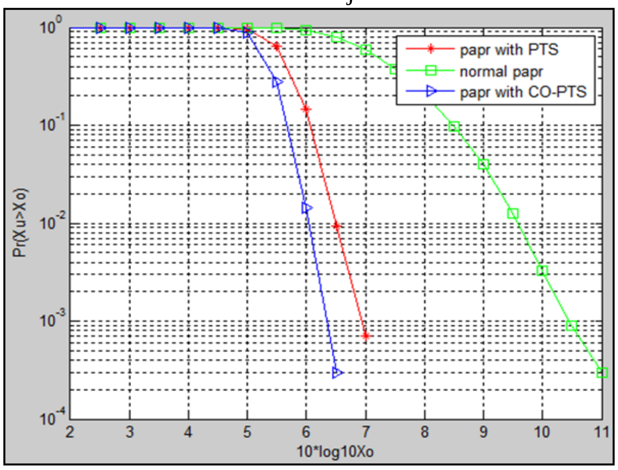

Fig. 6.2: PAPR performance of SFBC MIMO-OFDM signal in case 128subcarriers, 4 sub block and phase weighting factor ± 1

VI. Conclusion

The simulation results verify the ability of applying Conventional Partial Transmit Sequence on Multiple Input Multiple Output Orthogonal Frequency Division Multiplexing systems. Cooperative Partial Transmit

Sequence for Space Frequency Block Code Multiple Input Multiple Output Orthogonal Frequency Division Multiplexing system achieves more reduction in the Peak to Average Power Ratio. The proposed co-PTS makes use of alternate optimization to reduce peak to average power ratio. At the same time, the number of candidate sequences is increased by employing spatial sub block circular permutation, which improves PAPR reduction performance equivalently. The proposed technique gives better result of PAPR approximately 5.4dB with 8 sub block compared to PTS technique with MIMO-OFDM.

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