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Review of PAPR Reduction for MIMO-OFDM Systems for 5G Application using PTS Scheme

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ABSTRACT: Multiple Input Multiple Output (MIMO) in combination with Orthogonal Frequency Division Multiplexing (OFDM) is of great interest for researchers and research laboratories all over the world. OFDM is widely used in contemporary communication systems for its good robustness in multipath environment, and its high spectral efficiency. The capacity of wireless system can be increased dramatically by employing Multiple Input Multiple Output, (MIMO) antennas. The combination of MIMO and OFDM system is found to be very beneficial. A major drawback of OFDM-MIMO System is its high Peak to Average Power Ratio (PAPR) Reduction. The peak power of a signal is a critical design factor for band limited communication systems, and it is necessary to reduce it as much as possible. Many PAPR reduction techniques have been used to reduce PAPR. Partial transmit sequence (PTS) is one of the most well-known peak-to-average power ratio (PAPR) reduction techniques proposed for MIMO-OFDM systems. However the computational complexity of traditional PTS method is tremendous. In this paper studied of partial transmit sequence (PTS) technique, based on two antennas STBC MIMO-OFDM system, which can achieve better PAPR performance at much less complexity. The main idea behind this is to separate the input data vector, generated by Alamouti algorithm, into real and imaginary parts and separately multiplied with phase factors. The optimum weighting coefficient of antenna two can be directly obtained by appropriating mapping from that of antenna one which leads further to reducing complexity computation.

KEYWORDS: PTS, C-A-PTS, STBC, MIMO, OFDM, PAPR

I. INTRODUCTION

A combination of multiple input multiple output (MIMO) and orthogonal frequency division multiplexing (OFDM) (MIMO-OFDM) is an emerging technology for high speed data multi-carriers transmission in future wireless communication network systems such as digital audio broadcasting (DAB), digital video broadcasting (DVB), medical body area networks (MBANs) applications, the fourth and the fifth generation (4G,5G) of mobile network. In MIMO-OFDM system, the output is the superposition of multiple sub-carriers. Whenever, the phases and frequencies of these carriers match coherently, instantaneous power outputs may increase greatly and become higher than the mean power of the high power amplifier (HPA) resulting in large PAPR [1]. Lot of research work has been done for solving the problem of PAPR that concerns all kind of multicarrier signals. So, many techniques have been proposed such as clipping [2], tone reservation [3], nonlinear transformations [4], coding [5], selecting mapping (SLM) [6] and partial transmit sequence (PTS). Modified approaches of PTS are proposed in that produce better results; however, the computational complexity is still remaining unsolved totally. In this paper an approach is proposed to reduce the PAPR in STBC MIMO-OFDM systems with less computational complexity. So, the mean idea is based on separating the input vector data into real and imaginary parts for computational simplification reasons and then C-A-PTS is applied individually on these parts, moreover, PAPR is conjointly optimized in real part and imaginary part for the first antenna and by symmetry property the optimum weighting coefficient is deduced for the second antenna without any extra optimization which leads to decreasing of the complexity of the computation [7].

II. SYSTEM MODEL

MIMO in combination with OFDM is widely used nowadays due its best performance in terms of capacity of channels, high data rate and good outcome in frequency selective fading channels. In addition to this it also improves reliability of link. This is attained as the OFDM can transform frequency selective MIMO channel to frequency flat MIMO channels [8]. So it is widely used in future broadband wireless system/communications. Cyclic prefix is the copy of last

part of OFDM symbol which is appended to the OFDM symbol that is to be transmitted. It is basically 0.25% of the OFDM symbol. We can say that one fourth of the OFDM symbol is taken as CP (cyclic prefix) and appended to each OFDM symbol. IFFT is used at the transmitter and FFT is used at the receiver which substitutes the modulators and demodulators. Doing so eliminates the use of banks of oscillators and coherent demodulators. Moreover the complex data cannot be transmitted as it is; therefore it is first converted to analog form which is accomplished by IFFT. It basically converts the signal from frequency domain to time domain. Prior to IFFT operation symbol mapping is performed which is nothing but the modulation block. Any of the widely used modulation techniques can be applied like BPSK, QPSK, QAM, PSK etc. Further there are higher order modulations are also available which provide more capacity at little expense of BER performance degradation. After IFFT block pilot insertion is done and then CP (cyclic prefix) is added. Figure 1 below shows the block diagram constituting MIMO and OFDM. Any antenna configuration for the MIMO can be used according to the system requirement. Higher the configuration more will be the capacity and more will be the computational complexity of the transceiver design. It is seen that in the case of estimating channel the computational complexity is increased. Mapper defines the modulation to be used. Symbol encoder takes the shape of the STBC (Space Time Block Code) if spatial diversity is to be used and it takes the shape of the demultiplexer/multiplexer if spatial multiplexing is to be used.

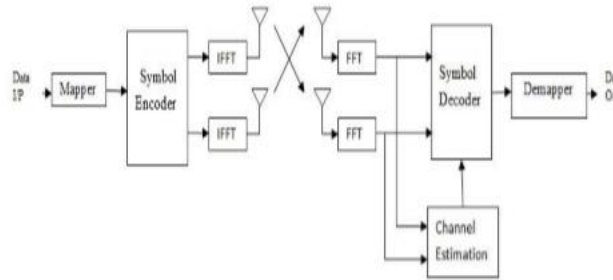


Figure 1: MIMO-OFDM system model

The received signal at j^{th} antenna can be expressed as

$$R_j[n,k] = \sum H_{ji}[n,k] X_i[n,k] + W[n,k] \quad (1)$$

Where H is the channel matrix, X is the input signal and W is noise with zero mean and variance. Also $b_i[n,k]$ represents the data block i^{th} transmit antenna, n^{th} time slot and k^{th} sub channel index of OFDM. Here i and j denoted the transmitting antennas index and receiving antenna index respectively.

The MIMO-OFDM system model [9] with N_R receives antennas and N_T transmits antennas can be given as:

$$\begin{bmatrix} Z_1 \\ Z_2 \\ \vdots \\ Z_N \end{bmatrix} = \begin{bmatrix} H_{1,1} & H_{1,2} & \dots & H_{1,N_T} \\ H_{2,1} & H_{2,2} & \dots & H_{2,N_T} \\ \vdots & \vdots & \ddots & \vdots \\ H_{N_R,1} & H_{N_R,2} & \dots & H_{N_R,N_T} \end{bmatrix} \begin{bmatrix} A_1 \\ A_2 \\ \vdots \\ A_{N_T} \end{bmatrix} + \begin{bmatrix} M_1 \\ M_2 \\ \vdots \\ M_{N_T} \end{bmatrix} \quad (2)$$

Where, Z represents O/P data vector, H denotes Channel matrix, A denotes I/P data vector and M represents Noise vector. The wireless channel used is AWGN channel. After receiving the signal the CP is removed then the pilots are also removed from main signal received. After this the signal that is in time domain can be again converted to frequency domain by taking FFT of the received signal.

The sequence on each of the OFDM block is then provided to channel estimation block where the received pilots altered by channel are compared with the original sent pilots. Channel estimation block consists of the algorithms that are applied to estimate the channel.

III. LITERATURE REVIEW

Zhitong Xing et al. [1], OFDM keeps on being sent in 5G correspondence frameworks and is probably going to be utilized in past 5G (B5G) correspondence frameworks also, because of its many benefits. In any case, one significant

disadvantage with OFDM frameworks is its high top to-average power proportion (PAPR), particularly with huge data transfer capacity transmissions. In this paper, we have given a regularization improvement based adaptable cross breed companding and cutting plan (ROFHCC) utilized for PAPR decrease in OFDM frameworks. To decrease the plan intricacy, the companding capacity has two sections. It limits the sign examples with amplitudes over a given worth to a consistent incentive for both pinnacle power decrease and little power pay. For signals with tests under a given adequacy, they are extended by a direct companding capacity. We construct a regularization enhancement model to mutually enhance the companding contortion as well as the congruity of the companding capacity for bit mistake rate (BER) execution as well as power unearthy thickness (PSD) execution. Reproduction results demonstrate that for a similar PAPR execution, the proposed companding plan enjoys an upper hand over the referred to companding plans. For instance, when the normal sign power is standardized to be 1, we pick both PAPR for ROFHCC plan and two-piecewise companding (TPWC) conspire as 4 dB, then, at that point, we can track down that at $BER=10^{-4}$, the base required E_b/N_0 for ROFHCC plot is around 2.3 dB lower than TPWC conspire.

H. Chen et al. [2], separated symmetrical recurrence division multiplexing (f-OFDM) is viewed as one of the contender for future portable correspondence due to its adaptable boundary setup for various situations. In any case, the impedance examination of f-OFDM is significantly difficult because of its unique handset structure, particularly in the uplink with non-ideal synchronization. The uplink obstruction of f-OFDM frameworks under non-ideal synchronization, in which transporter recurrence offset (CFO) and timing offset (TO) of numerous client gear (UE) are thought of, is examined in this review. The obstruction is ordered into a few sub-impedances. The shut structure articulations of each sub-obstruction and its difference are first inferred, and afterward checked by means of reproductions. Based on the inferred shut structure articulations, first, the impacts of non-ideal variables and framework boundaries, like CFO, TO, watch band (GB), and subcarrier dividing (SCS), on the uplink impedance of f-OFDM frameworks, are reproduced and examined. This study is confirmed by programmatic experiences, and the hypothetical inference of obstruction concurs with the reproduction result. Second, Hanning window channels are utilized by past f-OFDM frameworks, bringing about piece blunder rate (BER) awkwardness between sub-groups. Thus, the impact of waveform channel on the impedance and BER is likewise examined in this examination. Results demonstrate that preferable obstruction and BER exhibitions over Hanning window channels can be gotten by utilizing sensible channel settings. Besides, a few channel configuration rules are closed. In general, the examination and reenactments uncover numerous natural impedance attributes of f-OFDM, which will help the future f-OFDM framework plans.

S. Rajasekaran et al. [3], symmetrical recurrence division multiplexing (OFDM) has been one of the standard advances in the fields of current remote correspondences. In any case, its own high top to average power proportion (PAPR) issue can disable the presentation of framework, which has extraordinarily confined its wide applications. Incomplete send succession (PTS) was proposed for further developing the PAPR execution of OFDM frameworks. Be that as it may, its presentation extraordinarily builds the computational intricacy of the framework. In this paper, a low-intricacy PTS plot is proposed in view of the predominant time-area tests, and two new measurements for picking these examples are presented. Moreover, to additionally lessen the computational intricacy, gathering strategy has been engaged with proposed conspire. Reenactment results demonstrate that the proposed low-intricacy PTS plan can furnish an ideal PAPR decrease execution with more computational intricacy reserve funds.

Z. Zhou et al. [4], an original low-intricacy least sufficiency contrast (MAD) decoder is proposed for chosen planning (SLM)- based unevenly cut optical symmetrical recurrence division multiplexing (ACO-OFDM) noticeable light correspondence (VLC) framework. With the proposed plot, a particular arrangement of symmetric vectors is intended to limit the top to-average power proportion (PAPR) of sign without the transmission of side data (SI) and recuperate SI aimlessly by the proposed MAD decoder. Reproduction results show that the proposed plot diminishes the PAPR really and the cycle blunder rate execution of ACO-OFDM framework with MAD decoder is extremely near that of traditional chose planning (CSLM) conspire with greatest probability decoder, yet at much lower intricacy.

W. Hu et al. [5], this paper proposes another actual layer design in view of symmetrical recurrence division multiplexing (OFDM) for uplink different access. It focuses on high unwavering quality with fixed decoder inactivity focusing on emanant low-inertness remote applications, for example, transmission of control data in machine-to-machine (M2M) and gadget to-gadget (D2D) interchanges. Our proposed framework depends on the prudent mix of subcarrier bouncing and super-symmetrical convolutional codes for accomplishing high coding gain and recurrence variety, along with Golay integral successions for low top to-average power proportion (PAPR) flagging. The low

PAPR nature further develops the power effectiveness at a power intensifier (PA) and subsequently adds to the transmission range upgrade.

Y. Hori et al. [6], besides, by presenting non-symmetry among clients through the task of similar arrangement of subcarriers to different clients, the in general ghostly effectiveness can be gotten to the next level. To smother different access impedance brought about by the non-symmetrical cross-over of clients, multiuser discovery (MUD) is utilized. Hypothetical articulations of inexact bit blunder rate for the proposed framework with MUD are additionally evolved. Mathematical outcomes uncover that our proposed framework accomplishes higher unwavering quality and higher unearthly effectiveness than the customary symmetrical recurrence division different access (OFDMA)- based framework.

Ashna Kakkar et al. [7], Multiple input multiple output orthogonal frequency division multiplexing (MIMO-OFDM) is an attractive transmission technique for high-bit-rate communication systems. Like OFDM, one main disadvantage of MIMO-OFDM is the high peak-to-average power ratio (PAPR) of the transmitter's output signal on different antennas. The partial transmit sequences (PTS) approach provides optimal performance for PAPR reduction. However the computational complexity of traditional PTS method is tremendous. In this paper, a cooperative and alternate PTS (C-A-PTS) scheme for STBC MIMO-OFDM system is proposed which can achieve nearly optimum PAPR performance at much less complexity. The simulation results prove the effectiveness of the advanced algorithm.

Ho-Lung Hung et al. [8], they studied the impact of nonlinear devices on OFDMA signals. Therefore, they combine an OFDM modulation with an FDMA (Frequency Division Multiple Access) scheme. Their results allow an analytical spectral characterization of the transmitted signals, as well as the computation of the nonlinear interference levels on the received signals. They considered the nonlinear signal processing schemes which operate on a sampled version of the OFDM signal. They will take advantage of the Gaussian nature of OFDMA signals with many subcarriers for the analytical characterization of the transmitted signals. In, they presented an analytical tool to evaluate nonlinear distortion effects on systems employing OFDMA signals.

IV. PTS SCHEMES

1. SISO PTS Scheme

In the SISO-PTS scheme, the original data sequence in the frequency domain is partitioned into M disjoint, equal length sub blocks X_v ($v = 1, 2, \dots, M$) as follows.

$$X = \sum_{v=1}^M X_v \quad (3)$$

By multiplying some weighting coefficients to all the subcarriers in every subblock, we can get the new frequency sequence.

$$X' = \sum_{v=1}^M b_v X_v \quad (4)$$

Finally, at each transmitting antenna, there are $(V-1)$ sub blocks to be optimized, and the candidate sequence with the lowest PAPR is individually selected for transmitting. Assume that there are W allowed phase weighting factors. To achieve the optimal weighting factors for each transmitting antenna, combinations should be checked in order to obtain the minimum PAPR [10].

2. Alternate PTS (A-PTS)

In, the idea of alternate optimization is introduced, and it can be also applied to PTS in multiple antennas OFDM systems, denoted as alternate PTS (A-PTS). Different from ordinary PTS, phase weighting factors are needed only for half of the sub blocks in A-PTS. That is to say, starting from the first sub block, every alternate sub block is kept unchanged and phase weighting factors are optimized only for the rest of the sub blocks, which leads to the reduction of computational complexity. In this way, the computational complexity is greatly reduced at the expense of PAPR performance degradation [11]. Employed spatial sub block circular permutation for A-PTS scheme to increase the number of candidate sequences which improves the PAPR performance further.

3. Cooperative and Alternate PTS (C-A-PTS)

Based on the A-PTS and C-PTS schemes, the C-A-PTS is proposed to reduce the computational complexity in STBC MIMO-OFDM system. On the one hand, apply the APTS algorithm in a single antenna, and employ the linear property of inverse discrete Fourier transform (IDFT) to increase the number of candidate sequences so as to achieve better PAPR performance. On the other hand, utilize the conjugate and symmetric property to get the weighting coefficient of the other antennas in order to reduce the complexity. According to the linear property of IDFT, it can be deduced that the conjugate operation in frequency domain is equivalent to the circular permutation and conjugate operation in time domain.

The characteristics can be exploited to ameliorate the PAPR performance. At antenna 1, we adopt the optimal alternate PTS scheme to get the optimum weighting coefficient a_v ($v = 1, 2, \dots, M$) which achieves the minimum PAPR value. The linear property of IDFT is used for all the odd sub blocks (except the first one) to increase the number of the candidate signals. The transformed data in time domain can be obtained by performing the circular permutation and conjugate operation on all the odd sub-blocks (except the first one) instead of the IDFT or IFFT operation. Since the odd sub-blocks (except the first one) are transformed, the number of candidate sequences is increased which improves the PAPR performance of the single antenna, while the number of complex multiplications is not increased. It has been proved that the data on two antennas have the same PAPR statistical characteristics simultaneously. The correlation is utilized to reduce the complexity of MIMO PTS plan. The optimum weighting coefficient of antenna 2 can be directly obtained by appropriate mapping from that of antenna 1. Moreover the process of IFFT operation and optimum PTS weighting coefficient search can be omitted for the data at antenna 2. A block diagram of the C-A-PTS scheme with two transmit antennas is shown in Figure 2.

Next, the conversion of the optimum weighting coefficient is discussed. In order to maintain the conjugate and symmetric relations between the two antennas after scrambling sequence methods, we should convert the optimum weighting coefficient $a(\text{opt})$ at antenna 1 into that of antenna 2 denoted as $b(\text{opt})$ by the inverse conjugate and symmetric transformation. For example, when the optimum weighting coefficient $a(\text{opt})$ is $[1, 1, j, -j]$, the optimum weighting coefficient for antennas 2 is $b(\text{opt}) = [1, 1, -j, j]$. The advanced C-A-PTS scheme can be also applied to the STBC MIMO-OFDM system with more transmit antennas.

Based on C-A-PTS, an approach to solve the contradiction between the PAPR performance and computational complexity in STBC MIMO-OFDM system is proposed. Let us consider a STBC MIMO-OFDM system that employs Alamouti scheme. The coding matrix is:

$$G = \begin{pmatrix} x_1 & -x_2^* \\ x_2 & x_1^* \end{pmatrix} \quad (5)$$

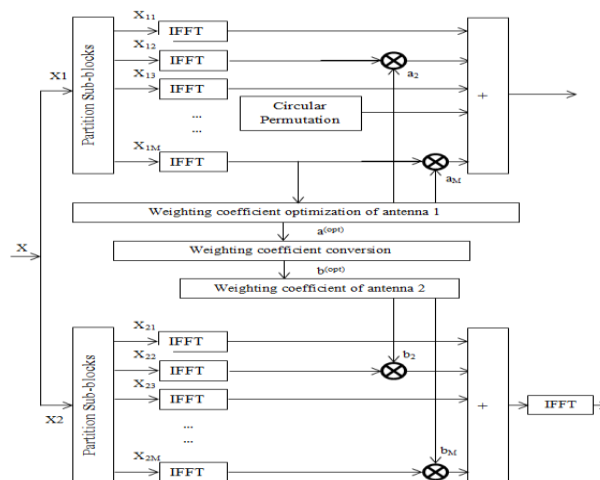


Figure 2: Block diagram of the C-A-PTS scheme with two transmit antennas

V. CONCLUSION

An extended approach cooperative and alternate partial transmit sequence named C-A-PTS was studied for STBC MIMO-OFDM which makes uses of conjoint optimization of the PAPR for both real and imaginary parts. A high PAPR, between the two antennas, is selected to be transmitted. This method performs well in terms of simulation results as well as the complexity of computation will be reduced.

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