

# Review of PAPR Reduction for MIMO-OFDM Systems in 4G Communication System

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**ABSTRACT:** In recent time, the demand for multimedia data services has grown up rapidly. One of the most promising multi-carrier system, Orthogonal Frequency Division Multiplexing (OFDM) forms basis for all 4G wireless communication systems due to its large capacity to allow the number of subcarriers, high data rate and ubiquitous coverage with high mobility. OFDM is significantly affected by peak-to-average-power ratio (PAPR). Unfortunately, the high PAPR inherent to OFDM signal envelopes will occasionally drive high power amplifiers (HPAs) to operate in the nonlinear region of their characteristic curve. The nonlinearity of the HPA exhibits amplitude and phase distortions, which cause loss of orthogonality among the subcarriers, and hence, inter-carrier interference (ICI) is introduced in the transmitted signal. Not only that, high PAPR also leads to in-band distortion and out-of-band radiation. This paper emphasis mainly on the PAPR reduction of MIMO-OFDM system using partial transmits sequence (PTS) and precoding techniques. Some other techniques such as amplitude clipping, Artificial Bee Colony have low-complexity; on the other hand, they suffer from various problems such as in-band distortion and out-of-band expansion.

**KEYWORDS:** PTS, STBC, MIMO, OFDM, PAPR

## I. INTRODUCTION

Orthogonal frequency division multiplexing (OFDM) is one of the most attractive technologies for fourth generation (4G) wireless communication. The basic principle of OFDM is to split a high-rate data stream into a number of lower rate streams that are transmitted simultaneously over a number of subcarriers. OFDM faces several challenges. The key challenges are large peak to average ratio due to non-linearity of amplifier; phase noise problems of oscillator, need frequency offset correction in the receiver. Large peak-to-average power (PAP) ratio which distorts the signal if the transmitter contains nonlinear components such as power amplifiers (PAs). This is because power amplifier at transmitter enters into saturation region instead of being in linear region which causes distortion to the transmitted signal which further results in increased BER at the receiver. In other words, the nonlinear distortion causes both in-band and out-of-band interference to signals. Therefore the PAs requires a back off which is approximately equal to the PAPR for distortion-less transmission. This decreases the efficiency for amplifiers. Therefore, reducing the PAPR is of practical interest.

OFDM has been proposed as a transmission technique to bolster rapid information transmission over remote connections in multipath situations. Amid the most recent forty years, OFDM has formed into a famous plan for wideband advanced correspondence, whether remote or over wires, utilized as a part of uses, for example, computerized TV and sound television, remote systems administration and broadband web access [6]. OFDM system also utilized digital-to-analog converters (DAC) and analog-to-digital converters (ADC) in its signal processing loop. To help high PAPR, a high accuracy DAC and ADC are required, which is exceptionally costly for a given examining rate of the framework. While, a low-exactness DAC and ADC would be less expensive, yet its quantization commotion will be noteworthy, and therefore it diminishes the SNR when the dynamic scope of DAC and ADC increments to help high PAPR. Along these lines, the PAPR diminishment is basic for an OFDM framework for accomplishing better power effectiveness, huge territory scope and low BER. Most of the wireless communication systems employed high

# International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

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Vol. 8, Issue 6, June 2019

power amplifier (HPA) at the output of transmitter to obtain sufficient transmits power for large area coverage. For achieving maximum power efficiency, the HPA is usually operated at or near the saturation region. When high peak power signal pass through such HPA, peaks are clipped non-linearly and inter-modulation distortion are induced at the output. This additional interference leads to an increase in BER.

MIMO has been developed for many years for wireless systems. One of the earliest MIMO to wireless communications applications came in mid-1980 with the breakthrough developments. . Since then, several academics and engineers have made significant contributions in the field of MIMO. Now MIMO technology has aroused interest because of its possible applications in digital television, wireless local area networks, metropolitan area networks and mobile communication. First, MIMO system greatly increases the channel capacity, which is in proportional to the total number of transmitter and receiver arrays. Second, MIMO system provides the advantage of spatial variety: each one transmitting signal is detected by the whole detector array, which not only improved system robustness and reliability, but also reduces the impact of Inter symbol interference (ISI) and the channel fading.

## II. LITERATURE REVIEW

**Tanairat Mata et al. [1]**, A high PAPR is well known as the serious problem of OFDM system because of a huge degradation of its signal quality, especially in the non-linear channel. From the reason, many PAPR reduction schemes have been proposed for solving this problem. The Partial Transmit Sequence (PTS) scheme is one of the PAPR reduction schemes which can improve the PAPR performance effectively. However, its computational complexity would be increased which is proportional to the increasing number of symbol clusters in the optimum PAPR value for a PAPR reduction process. To solve this problem, this paper proposes the PAPR reduction scheme based on the improved PTS with Artificial Bee Colony (ABC) algorithm for OFDM system. The potential capability of the proposed scheme is the PAPR reduction performance with low computational complexity which leads to the improvement of signal quality in the OFDM system. The excellent PAPR reduction performance with the low computational complexity of the proposed scheme has been verified by the computer simulations in this paper.

**Thana Udomsripaiboon et al. [2]**, this article displays a novel procedure that decreases the crest to-average power proportion (PAPR) in the enormous scale MIMO-OFDM frameworks. It is a blend of two principles organizes a variable cut-out level and an Adaptive Optimizer that takes favorable position of the channel state data (CSI) sent from all clients in the cell. The outcomes demonstrate that the proposed strategy accomplishes a superior generally speaking framework execution than that of ordinary pinnacle decrease frameworks as far as the image blunder rate. Thus, the direct yield of the power enhancers can be limited with an extraordinary sparing in expense.

**Ashna Kakkar et al. [3]**, 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. [4]**, 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.

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Vol. 8, Issue 6, June 2019

**P. Kothai et al. [5]**, they proposed the novel transceiver schemes for the MIMO interference channel based on the mean square error (MSE) criterion. Their goal is to optimize the system performance under a given feasible degree of freedom. They also proposed tire robust MSE based transceiver schemes that take channel estimation error into account. In specific, two types of MSE were studied. One is the total MSE among all users without considering user fairness, and the other is the maximum per-user MSE when user fairness is concerned. In, the channel model used in the simulations is a quasi-static flat Rayleigh fading channel. They also proposed robust Sum-MSE Minimization and Min-Max algorithm in the presence of channel estimation errors.

**Muhammet Nuri Seyman et al. [6]**, they provided analytical framework for calculating the large-system throughput of a MIMO cellular network with channel estimation errors. The studies assumed that each AP only decodes the users in its service region without AP cooperation. If the average path gain of one link is relatively low, ignoring its contribution is worth consideration while slightly sacrificing system performances but greatly reducing system complexity. In addition to the optimal MMSE detector, this study also utilizes the suboptimal but simple linear MMSE (LMMSE) detector. It finally, they have reported that the weak path hardly contains useful information, and the additional training segment seems to be wasted and decrease the available data transmission period.

**P. Mukunthan et al. [7]**, the reported scheme is capable of dynamically sensing unused spectrum segments in a target spectrum pool, and communicating via the unused spectrum segments without causing harmful interference to the primary users. Their goal is to keep the primary user's rate unchanged while maximizing the CR user's rate. It is reasonably assumed that die CR can obtain this request information in the beginning of a service session, and apply the proposed method in the remainder of that session. The work verified the asymptotic correctness of the proposed sub-optimal methods.

**L. Yang et al. [8]**, the channels are considered as slow time-varying and, moreover, the fraction of time dedicated to the transmission of training data must be small to maintain the overall system spectral efficiency. Their policy can be adopted when no channel state information is available at tire transmitter. This is advisable to find a suitable suboptimal setting for the LMMSE channel estimator, such that the estimator itself would can provide good performance, regardless of the unknown real channel correlation conditions. However, this appears to be a very stringent requirement for mobile communication systems, and at the beginning of any wireless transmission.

### III. MIMO-OFDM 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.

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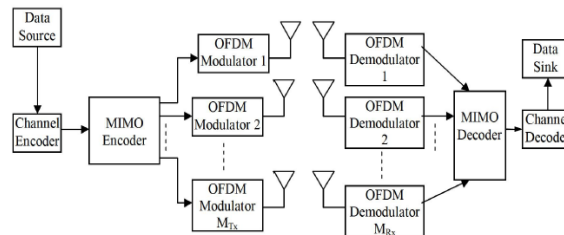


Figure 1: MIMO-OFDM system

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

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

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  $i^{\text{th}}$  transmit antenna,  $n^{\text{th}}$  time slot and  $k^{\text{th}}$  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  $NR$  receives antennas and  $NT$  transmits antennas can be given as:

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

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.

## IV. PTS SCHEMES

Several PAPR reduction techniques are available in the literature. These methods are basically divided in four categories:

- Signal Distortion.
- Coding Methods,
- Probabilistic (Scrambling) Techniques
- Pre-distortion Methods.

Every method has some drawbacks and merits. There is always a trade-off between PAPR reduction and some other factors like bandwidth, computational complexity, average power etc. An ideal PAPR reduction technique should have following characteristics:

- High capability of PAPR reduction with few harmful side effects such as in-band distortion and out-of-band radiation.

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Vol. 8, Issue 6, June 2019

- Low implementation complexity: Due to high implementation and computational complexity the delay in transmission increases which reduces data rate.
- Low average power: any increase in average power requires a larger linear operation region in HPA and thus resulting in the degradation of BER performance.
- No bandwidth expansion: The bandwidth is a costlier resource for any wireless communication systems. Therefore, it is required to reduce PAPR without increasing bandwidth of transmitted signal. The bandwidth expansion directly results in the data code rate loss due to side information. Therefore, the loss in bandwidth due to side information should be avoided or at least be kept minimal.
- No BER performance degradation: The PAPR should be reduce but not at the cost of BER reduction. The BER performance should be same as that of the original OFDM system.
- Without additional power needed: Any increases in power requirement reduce the efficiency of system, and power is an important resource for any wireless communication system. Therefore, it is necessary for any PAPR reduction scheme to reduce PAPR without increasing power requirement.
- No spectral spillage: The PAPR reduction techniques should not destroy the inherit feature (orthogonally) of OFDM signal.

Many PAPR reduction techniques are proposed in the literature. In this section, we investigate some such techniques and discuss their advantages and disadvantages in terms of PAPR reduction capability, BER degradation and computational complexity [4, 5]. The PAPR reduction schemes are majorly divided into two categories

- a) Distortion Based Techniques
- b) Non-distortion Techniques

## PAPR Reduction Technique

### 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.

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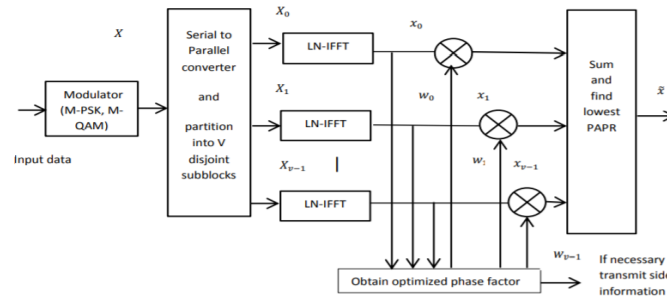


Figure 2: Block diagram of the PTS scheme with two transmit antennas

### 3. Artificial Bee Colony Technique

To decrease the computational complexity of the PAPR reduction process in IPTS scheme. The ABC algorithm is applied for determining the weighting factors in the IPTS scheme which can achieve better the PAPR performance with low computational complexity.

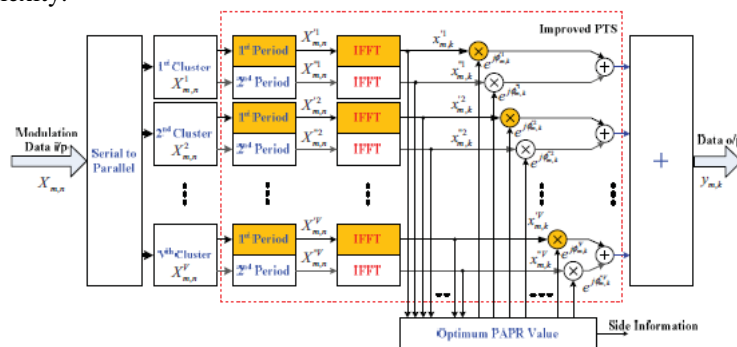


Figure 3: Block Diagram of the PTS with Artificial Bee Colony Technique

## V. CONCLUSION

The review of different types of PAPR reduction technique and PTS with Artificial Bee Colony (ABC) technique is best compared to other technique. ABC technique was applied 256 and 512 inverse fast fourier transform and calculate 6.8 dB PAPR. The further work of this technique is replace Artificial Bee Colony with DWT-DCT technique and achieved good PAPR reduction will be calculated in final paper.

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