

PAPR Reduction Using BPSO/PTS and STBC in MIMO OFDM System

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Abstract: Problem statement: The Multiple Input Multiple Output (MIMO) Orthogonal Frequency Division Multiplexing (OFDM) system has been receiving a great attention, as one of solutions for achieving high speed, efficient and high-quality service for the wireless communications. However, the transmitted signal still has high PAPR because of OFDM characteristics. Many methods have been proposed to solve this problem, but the most of them decrease high Peak-to-Average Power Ratio (PAPR) as well as the data rate. **Approach:** This proposal described a new suboptimal technique for reduction of the PAPR by combining two suitable methods for MIMO OFDM systems. The first method was based on Boolean Particle Swarm intelligence Optimization (BPSO) applied to Partial transmit Sequence (PTS) and the second was the Space Time Bloc Coding (STBC). **Result:** Apply only the PTS technique and independently on each transmitted antenna, was effective to reduce PAPR, but it requires high computation complexity. Therefore, the BPSO/PTS technique provided better performance and it was been promoted as an uncomplicated way for PAPR reduction. Thanks of the BPSO/PTS algorithm; the transmitted sequence was selected with minimizing the maximum PAPR over all transmission antennas. The simulations and the BER performance demonstrated that more inertia weight and phase weighting factor obtained better PAPR reduction performance without bringing much higher complexity. **Conclusion:** Results show that the added BPSO/PTS method to orthogonal space time bloc coding minimizes computational complexity cost as well as the PAPR and gives best optimal PTS performance in comparison with the conventional methods.

Key words: Peak reduction, computational complexity minimized, Binary Error Rate (BER), Signal to Noise Ratio (SNR), Worldwide Interoperability for Microwave Access (WIMAX), Power Amplifier (HPA)

INTRODUCTION

The growing development of the telecommunication world increases the need for spectral resources, especially that those are more and more rare and expensive, so the use of the multiplexing techniques in particular the modulations multi-carrier is thus a very useful mean to better optimize these resources. Several techniques permitting a better use the spectral band of the channel exist, such as that Orthogonal Frequency Division Multiplexing used in wireless communications systems.

Therefore, the Orthogonal Frequency Division Multiplexing (OFDM) is reputed favorable, due to the security level it offers and its great resistance to the interferences, for the most of telecommunications technologies like the DAB (Digital Audio

Broadcasting), the Digital Video Broadcasting (DVB-T), the Digital Asymmetric Subscriber Line (ADSL), the High Performance Radio Local Network (HIPERLAN) and the Worldwide Interoperability for Microwave Access (WIMAX).

Indeed, this technique undergoes a lot of successes recently thanks to their intrinsic hardness to the selective canals in frequency and their sufficient robustness to radio channel impairments (Krongold and Jones, 2003). This is the one of the reasons which makes the modulation OFDM used for Multiple Input Multiple Output (MIMO) technology on which we concentrated in this project.

Nevertheless, the OFDM signals possess a very wide band and present also a big variation of amplitude. Now, this characteristic is the very sensitive return to the not-linearity of the analogical components, in

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particular the one of the Power Amplifier (HPA). In fact, the HPA are conceived to work in their saturation zone (for a yield maximum) now unfortunately this is in this zone that presents itself the not-linear harsher. The use of the HPA in his saturation zone provokes the inter-modulation, distortions inside the band and ascents of the lob secondary that generate interferences between canals and an increase of the rate of Binary Error Rate (BER) (Nasseri and Bakhshi, 2010).

A several suggestions has been proposed to treat this problem of non linearity, more than a few of them reduces the PAPR and proves itself very effective to relieve overcome problems at the HPA. But, some of these methods treated in (Davis and Jedwab, 1999) and (Tellado, 2000) are based on coding, in which some bit combinations are sacrificed to eliminate high-peak PAPR patterns while the peak power is reduced as well as the data rate.

Therefore, in this study we exploit PAPR reduction technique called Partial Transmit Sequence combined to BPSO algorithm by according to (Han and Lee, 2003; Wen *et al.*, 2008) and (Suyama *et al.*, 2009), to make an efficient method to reduce PAPR in STBC MIMO OFDM system with low computational complexity cost.

Hence, we simulate a model of MIMO OFDM system based on QPSK modulation, by using the space time bloc coding with BPSO PTS algorithm to reduce the PAPR. Then, we evaluate the system performances in terms of BER (Binary Error Rate). Of this fact, we concluded that the proposed method is distinctly more resistant to the effects of PAPR than original PTS techniques described in (Han and Lee, 2003) and also less computational complicated thanks to BPSO algorithm.

MATERIALS AND METHODS

System model: We consider a STBC MIMO OFDM system that employs Alamouti scheme (You and Paik, 2003). A space time block coding is independently applied to each subcarrier (Alamouti, 1998). Although several encoding schemes are available for an arbitrary number of transmit antennas, we consider only two transmit antennas for notational simplicity in this study and the Fig. 1 shows the scheme of our system model.

Based on this scheme, we perform a new method using space time bloc coding combined to BPSO/PTS technique to reduce the PAPR of MIMO OFDM systems as well as computational complexity. We will show that our proposal scheme can provide better performance with low complexity in section of simulation results.

So, the main problem in the MIMO OFDM system is the relatively high PAPR. Before displaying the proposed method for reducing the PAPR, let's define the PAPR calculated relation first:

$$\text{Papr}(s(t)) = \frac{|s(t)|_{\infty}^2}{E|s(t)|_{\infty}^2/N} \quad (1)$$

Where, $s(t)$ is the time domain sequence constructed by evaluating N point Inverse Fast Fourier Transform IFFT.

So, mathematically during the first symbol period, the OFDM symbol transmitted from the first antenna is denoted X_1 and from the second antenna is X_2 . For two transmit antennas, each input symbol vector corresponding to the N subcarrier is defined as:

$$X(N) = [X_1(N) X_2(N)]^{\text{Transpose}} \quad (2)$$

Further, a STBC encoder generates coded data symbols by applying Alamouti encoding scheme described in (Alamouti, 1998), resulting in Eq. 3:

$$s(N) = \begin{bmatrix} X_1(N) & X_2(N) \\ X_2^*(N) & X_1^*(N) \end{bmatrix}^{\text{Transpose}} \quad (3)$$

As shown in Fig. 1, the information symbol at time is encoded by the STBC encoder as N code symbols. Each code symbol is transmitted, simultaneously, from a two antennas. The encoder chooses the N code symbols to transmit so that both the coding gain and diversity gain at the receiver are maximized.

The proposed BPSO/PTS: Partial Transmit Sequences is the distortion less method for PAPR reduction in MIMO OFDM. A block scheme describing this method is represented in Fig. 1 as BPSO/PTS. Input data are mapped according chosen QPSK constellations and split into OFDM symbols. Each symbol is then partitioned into distinct subblocks and each subblock is completed by zeros to original symbol length but after the space time bloc coding which give rise to two independent resulting signals corresponding to each antenna (Han and Lee, 2003). Then, subsequently zero padding and Inverse Fast Fourier Transform (IFFT) on each subblock are used. After the IFFT, these subblocks are multiplied by combination of constants $+1$ and -1 . Finally, the whole symbol is calculated as a sum of all multiplied subblocks (Wen *et al.*, 2008).

For PAPR reduction at the MIMO case, a suboptimal method is used based on the PTS technique corrected by BPSO algorithm (Xiao *et al.*, 2007).

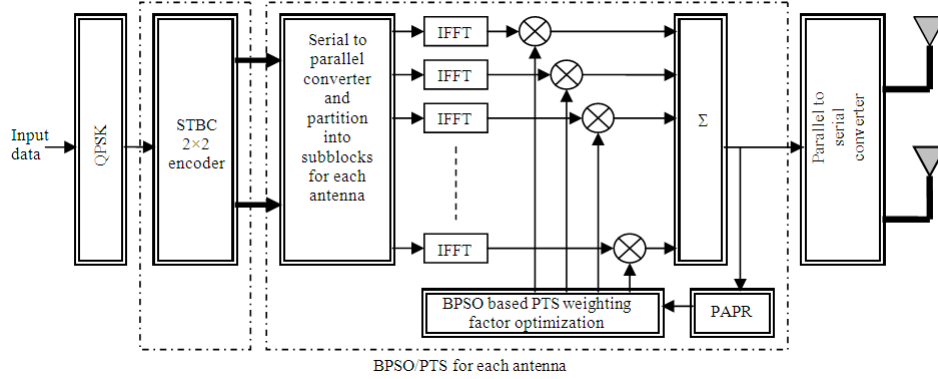


Fig. 1: Scheme of system model

In Particle Swarm Optimization, the usual iterative form is the following one:

$$\begin{cases} V_{t+1} = \alpha v_t + \beta \phi y_t \\ y_{t+1} = -\gamma v_t + (\delta - \eta \phi) y_t \end{cases}$$

$$\phi \in \mathfrak{R}^*$$

$$\forall t \in \mathbb{N}, \{y_t, v_t\} \in \mathfrak{R}^2$$
(4)

Where, v is the velocity of the particle, so it has indeed to be equal to zero in a convergence point.

Where:

$$y_t = p - x_t$$
(5)

The matrix of the system is:

$$M = \begin{bmatrix} a & \beta \phi \\ -\gamma & \delta - \eta \phi \end{bmatrix}$$
(6)

We just have to define:

$$\phi = \phi_1 + \phi_2 \text{ and } p = \frac{\phi_1 p_1 + \phi_2 p_1 + \phi_2 p_2}{\phi_1 + \phi_2}$$
(7)

To obtain the resolution of the system presented below. In fact, ϕ_1 and ϕ_2 are uniform random variables between 0 and $\phi_{\max 1}$ and $\phi_{\max 2}$ respectively.

For the duration of the BPSO algorithm, each potential solution is represented as a particle with a position vector x , referred to as phase weighting factor and a moving velocity represented as v , so this process can be used to reduce the computational complexity by searching the PAPR values through phase optimizer. Once the PAPR drops below the preset threshold, the

search is achieved successfully. Therefore, the computational complexity can be considerably reduced.

The expected goal using this combination is to have a low PAPR solution with less computational complexity. The PTS approach partitioned the input data block of MIMO OFDM system into disjoint sub-blocks (Wen *et al.*, 2008). Then, each sub-block is multiplied by the weighting factor, which is obtained by the optimization algorithm to reduce the PAPR value. Therefore, the BPSO algorithm is used in exhaustive and heuristic search for appropriate combination of each sub-block and its corresponding phase factors. So, with the optimized weighting factor the PAPR reduction become more efficient and easy to obtain (Xiao *et al.*, 2007).

In order to reduce the PAPR, the combination of STBC coding and BPSO/PTS is investigated. Both the space time block coding algorithm and the PTS technique using BSPO algorithm to OFDM signal. Afterwards, the symbols vectors are chosen with the minimum PAPR as optimized transmitted vector for a different number of generations due to the limited phase weighting factor.

RESULTS

We consider an MIMO OFDM system with 2 antennas that uses N subcarriers, employing QPSK modulation. Simulations have been performed using MATLAB software. We generate 17000 random MIMO OFDM frames. After applying the STBC coding and BPSO/PTS method, each block of N data symbols are transmitted in parallel such that each modulates a different subcarrier. We consider here the oversampling factor $L=4$. In Fig. 2-4 above, we describe CCDF of the PAPR simulated in the MIMO OFDM signals at each antenna for different subcarriers ($N=256, 512$ and 1024) by examining the number of particle generations G_n .

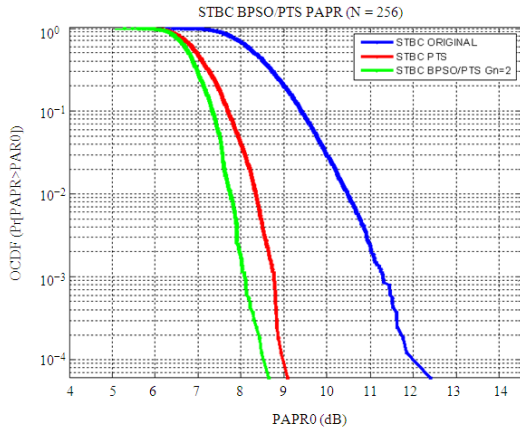


Fig. 2: CCDF of Suboptimal BPSO/PTS STBC 2x2 in MIMO OFDM system for 256 subcarriers (Gn=2)

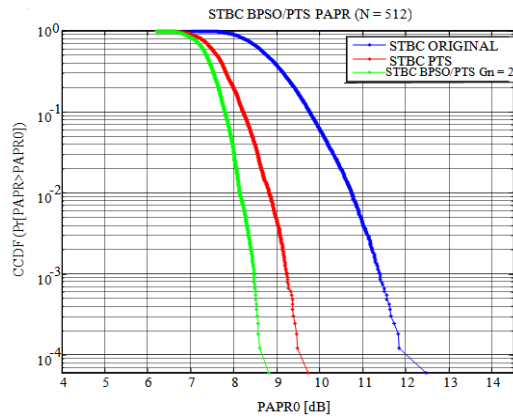


Fig. 3: CCDF of Suboptimal BPSO/PTS STBC 2x2 in MIMO OFDM system for 512 subcarriers (Gn=2)

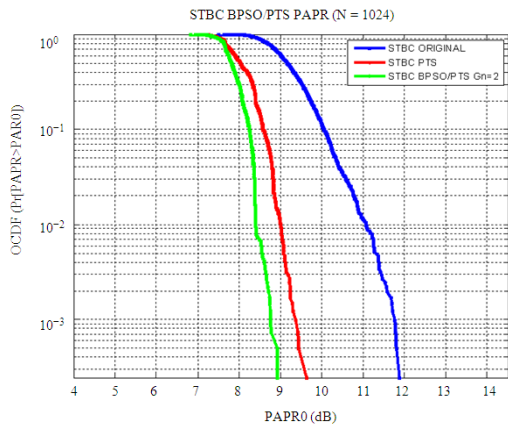


Fig. 4: CCDF of Suboptimal BPSO/PTS STBC 2x2 in MIMO OFDM system for 1024 subcarriers (Gn=2)

DISCUSSION

The CCDF definition is given as complementary cumulative distribution function (Han and Lee, 2005). The proposed method can reduce the PAPR more than the original STBC minimum by 4db for 256 subcarriers and maximum by 3dB for 1024 subcarriers.

From these figures (Fig. 2), it is worth noting that the PAPR is gradually promoted upon decreasing the number of subcarriers for a stable number of generations due to the limited phase weighting factor ($G_n = 2$), which was more complicated to reduce the PAPR as well as the number of subcarriers increase by using just the PTS technique in MIMO OFDM system.

With a fixed $V=16$ and $M=4$, it is clear that the PAPR reduction are achieved at 4.5dB by comparing with performance obtained for the original STBC 2x2 signal.

The Bit Error Rate (BER) as a function of Signal to Noise Ratio (SNR) is shown in the Fig. 5.

As usual, the combination of BPSO PTS and STBC results in improved noise immunity than independently used PTS STBC.

Apparently, more inertia weight and phase weighting factor can obtain better PAPR reduction performance without bringing much higher complexity in comparison of the STBC PTS technique, which appears clearly on the figure of BER.

Thus, the performance of suboptimal STBC BPSO/PTS technique is better in complexity for larger subcarriers in every update of the numbers of particle generations. Moreover, it can be observed that probability of very high PAPR can be decreased appreciably if BPSO/PTS technique is used and the performance of the PAPR reduction becomes better and also the processing time gets short since of little iteration.

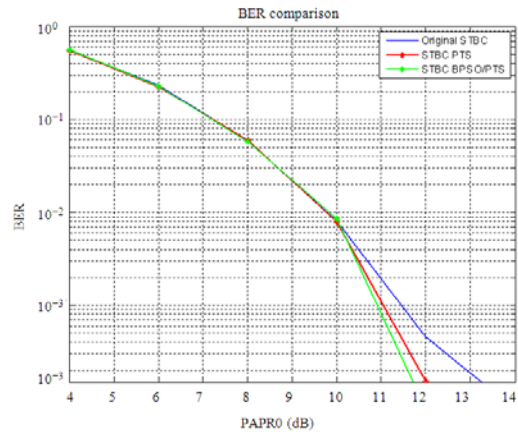


Fig. 5: BER performance versus SNR assuming equal for BPSO/PTS STBC 2x2 in MIMO OFDM system (Gn=2)

CONCLUSION

In this study, an optimal and less complicated solution to minimize efficiently a high peak below some amplitude has been investigated. The simulation results show that as the number of generations of particle swarm increase, PAPR can be further reduced. Therefore, the suboptimal technique BPSO/PTS added to STBC exhibits significant PAPR reduction performance with very limited complexity.

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