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Research paper



PAPR Reduction in MIMO-OFDM Using Modified PTS Scheme With Hybride ABC-FF Algorithem

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Abstract

Orthogonal Frequency Division Multiplexing (OFDM) is an admired method for high data rate wireless transmission. OFDM can be clubbed with antenna arrays at the transmitter and receiver to increase diversity gain to enhance the system capacity on time variant and frequency selective channels, resulting in (Multi input and Multi output)MIMO. One main flaw of MIMO-OFDM is that the signals transmitted on different antennas might exhibit a prohibitively large Peak-to-Average Power Ratio (PAPR). There are two techniques mainly used to mitigate the effect of PAPR namely Partial Transmit Sequence (PTS) and Selective Mapping (SLM). In this paper a new optimized Partial Transmit Sequence (PTS) scheme and SLM for PAPR reduction in MIMO-OFDM have been proposed. Both the techniques are connected in series to get efficient throughput. Hybrid of ABC–FF algorithm has been intended for optimal phase factor. The proposed technique has achieved better results than existing techniques. This intended technique has been implemented on the working platform of MATLAB.

Keywords: *MIMO-OFDM, PTS, SLM, PAPR and ABC-FF*

1. Introduction

The increasing developments in telecommunication raised the need for efficient usage of spectral resources, the multiplexing techniques in particular. The multi-carrier modulations are widely used to optimize these resources [1]. Orthogonal Frequency Division Multiplexing (OFDM) is one of the multi-carrier modulation techniques which divides the available spectrum into many carriers; each one is modulated by a low data rate stream [2]. OFDM is used for high data rate wireless communications because of its robustness to frequency selective fading, high spectral efficiency and low computational complexity [3] [4]. It is employed in wireless applications such as Digital Audio Broadcasting (DAB), Digital Video Broadcasting (DVB-T), the ETSI HIPERLAN/2 standard, the IEEE 802.11a standard for Wireless Local Area Networks (WLAN) and the IEEE 802.16a standard for Wireless Metropolitan Area Networks (WMAN) [1, 5, 6, 7, 8, and 9].

One of the main limitations of OFDM system is the high Peak to Average Power Ratio (PAPR) of the transmitted signal [9, 10, 11, and 12]. The high peaks of an OFDM signal are produced due to the addition of sub symbols of each subcarrier coherently.So these signals may cause many problems including a severe power penalty at the transmitter [7]. Therefore, it is necessary to reduce the PAPR of an OFDM signal [6]. Many techniques have been proposed to overcome the PAPR problem in the OFDM [13], which are classified into two types namely, distortion based techniques and redundancy-based techniques [14, 10].The distortion-based techniques such as direct clipping, peak windowing, Recursive Clipping and Filtering (RCF) etc., are used to reduce the PAPR of the OFDM symbol by adding distortion to the signal points in the subcarriers. The redundancy-based techniques such as coding, Selective Mapping (SLM), Partial Transmit Sequences (PTS), Tone Reservation (TR) and Tone Injection (TI), etc. are used to increase the average power due to the introduction of redundancy [10].

Among these methods, the PTS is one of the most emerging schemes because of high-quality PAPR reduction performance with no limitation to the number of subcarriers [15]. In the PTS scheme, the input data block of N symbols is divided into many disjoint sub blocks [16]. After that, each sub block is transformed to obtain the corresponding time-domain signal using Inverse Fast Fourier Transform (IFFT) and each one is multiplied by a rotation phase factor [15]. The objective of the PTS technique is to select the phase factor of the combined signal to minimize the PAPR [16]. This requires a number of iterations to be performed to find the optimum combination of phase factors for sub blocks [21], which results in the search complexity and increases exponentially with the number of sub blocks [3].

Multiple Input Multiple Output (MIMO) technology has numerous advantages including the ability to improve the system capacity and increasing the communication reliability through the diversity gain [17].For high data rate wireless applications such as in IEEE 802.16 d/e WIMAX, OFDM is combined with MIMO technology [18]. Like OFDM, a serious problem in MIMO-OFDM system is, its high Peak to Average Power Ratio (PAPR) [8]. Several researche contributions have been found in the literature to solve the problem of PAPR in MIMO-OFDM.

2. Proposed Methodology

The main aim of this research is to offer a better technique to reduce the PAPR in MIMO-OFDM system by solving the drawbacks that currently exist in the literary works. Hence, it is intended to propose a new optimized Partial Transmit Sequence (PTS)

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scheme and SLM for PAPR reduction in MIMO-OFDM. The introduced SLM and PTS scheme is based on combining the phase-shifted signal sub blocks as classical, however incorporated with optimized sub-block features. Moreover in the PTS scheme, the corresponding phase factor of each signal can be obtained by using the Artificial Bee Colony-Fruit Fly (ABC-FF) algorithm. Further, to improve the performance of the proposed scheme, Fruit Fly algorithm has been combined with the ABC algorithm which decreases the searching complexity of suitable phase factor. By the hybrid work of the two algorithms, the complexity of PAPR reduction will be greatly reduced along with the utilization of PTS scheme efforts .This technique will be implemented in the working platform of MATLAB and the results will be analyzed to demonstrate the performance of the proposed PAPR reduction in MIMO-OFDM using modified PTS scheme.

2.1 Peak to Average Power Ratio

To search existing design models or study an available new design model with required specifications and to establish the topological structure of these models are the first step of the methodology. The goal of this step is to select some of these models for researching their equivalent mechanism skeleton and kinematic chain for developing the new designs.

The transmitted signals in an Orthogonal Frequency-Division Multiplexing (OFDM) system can have high peak values in the time domain since many subcarrier components are added via an Inverse Fast Fourier Transformation (IFFT) operation. As a result, OFDM systems are known to have a high Peak-to-Average Power Ratio (PAPR) when compared to single-carrier systems. In fact, the high PAPR is one of the most detrimental aspects in an OFDM system as it decreases the Signal-to-Quantization Noise Ratio (SQNR) of the Analog-Digital Convertor (ADC) and Digital-Analog Convertor (DAC) while degrading the efficiency of the power amplifier in the transmitter. As a side note, the PAPR problem is more of a concern in the uplink since the efficiency of the power amplifier is critical due to the limited battery power in a mobile terminal.

The PAPR of a signal is expressed by the following formula:

$$PARP_{dB} = 10\log\left(\frac{\max[b(t)b*(t)]}{E[b(t)b*(t)]}\right) \quad (1)$$

Where b* corresponds to the conjugate operator. Since an OFDM symbol can be expressed as a sum of complex tones equally spaced in frequency, by calculating the PAPR of a single complex tone. Consider a complex tone signal:

$$b(t) = e^{2\Pi ft} \quad (2)$$

T is a Time period. The peak value of the signal is:

$$\max[b(t)b*(t)] = \max[e^{2\Pi ft}e^{-2\Pi ft}] = \max[e^{0}] = 1 \quad (3)$$

The mean square value of the signal is:

$$E[b(t)b*(t)] = E[e^{2\Pi ft}e^{-2\Pi ft}] = 1 \quad (4)$$

This gives us a PAPR of 0 dB. Consider that an OFDM time signal is made of *M* complex tones (usually called subcarriers). Our signal can be represented by the following formula:

$$b(t) = \sum_{0}^{M-1} a_k e^{\frac{j2\Pi mt}{T}} \quad (5)$$

Let us assume $a_k = 1$ for any *M*. In this scenario, the peak value of the signal

$$\max[b(t)b*(t)] = \max\left[\sum_{0}^{M-1} a_k e^{\frac{j2\Pi mt}{T}} . \sum_{0}^{M-1} a_k * e^{\frac{-j2\Pi mt}{T}}\right]$$
$$= \max\left[a_k a_k * \sum_{0}^{M-1}\sum_{0}^{M-1} e^{\frac{j2\Pi mt}{T}} e^{\frac{-j2\Pi mt}{T}}\right]$$
$$= M^2 \quad (6)$$

The mean square value of the signal is:

$$E[b(t)b*(t) = E\left[\sum_{0}^{M-1} a_k e^{\frac{j2\Pi mt}{T}} . \sum_{0}^{M-1} a_k * e^{\frac{-j2\Pi mt}{T}}\right]$$
$$= E\left[a_k a_k * \sum_{0}^{M-1}\sum_{0}^{M-1} e^{\frac{j2\Pi mt}{T}} e^{\frac{-j2\Pi mt}{T}}\right]$$
$$= M \quad (7)$$

The PAPR of an OFDM symbol with *M* subcarriers, with each subcarrier having the same modulation, is simply *M*.

Still, if we take a look at the 802.11a numbers, an OFDM symbol would have a PAPR around 17 dB (since M=52), which is fairly high. However, this number is the worst-case scenario and the probability of getting this high number is very unlikely as the modulated data on each subcarrier is theoretically random and uncorrelated. For this reason, the PAPR of an OFDM system is usually interpreted as a random variable with a distinct Probability Density Function (PDF).

2.2 PTS Technique

The above original designs are transformed individually into their corresponding generalized chains (kinematic chains). The generalized chain will be involved in various types of members (edges) and joints (vertices, or said kinematic pairs) for all possible assembly in the following steps.

Main idea of PTS is that the data blocks are divided into non overlapping sub-blocks with independent rotation factor. This rotation factor generates time domain data with lowest amplitude. This is the modified technique of SLM which gives the better performance than SLM. The block diagram of the PTS scheme is given in figure 1.

The block diagram for PTS technique implementation is shown in figure1. The data sequence *B* in frequency domain is sub-divided into *m* sub-sequence which are transmitted in sub-blocks without overlapping and having equal size of *N* containing *N/m* non-zero values in each sub-block.With the assumption that the sub-blocks have equal size without any gap between them. Thus the sub-block vector in frequency domain can be written as follows.

$$B = \sum_{m=1}^{M} x_m B_m \quad (8)$$

Where, $x_m = e^{i\theta m}$, $\theta_m = (0 - 2\pi)$, $m = 1,2,.....B_m$, θ is the set including *m* phase factors.

The time domain for the sub-block vector can be applied by IFFT function is:

$$b = IFFT(B) = \sum_{m=1}^{M} x_m B_m \quad (9)$$

Where, B_m is the Partial Transmit Sequence.

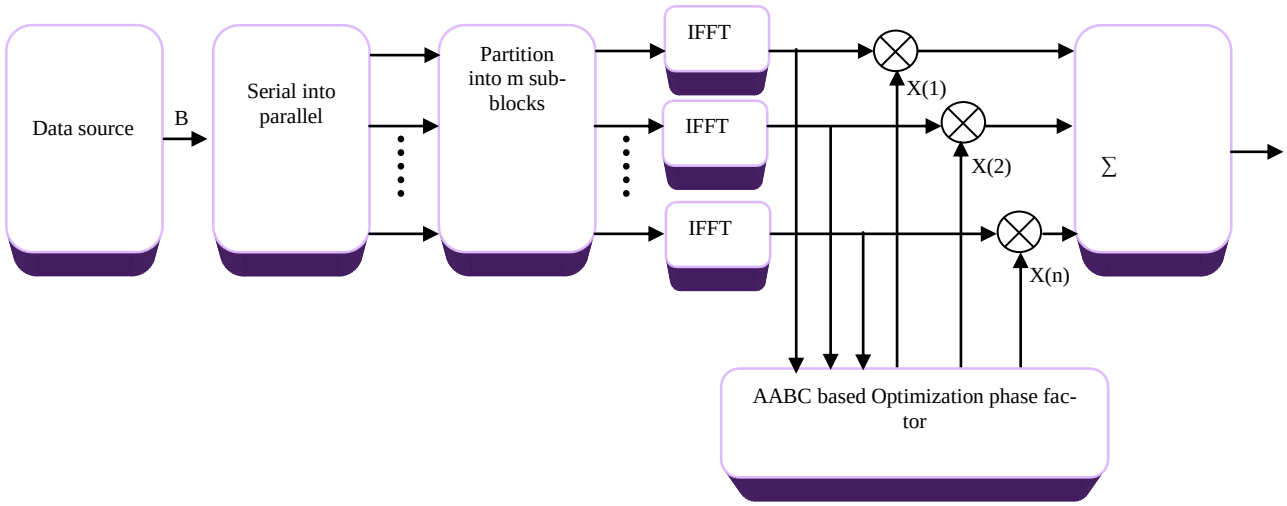


Fig 1:PTS scheme

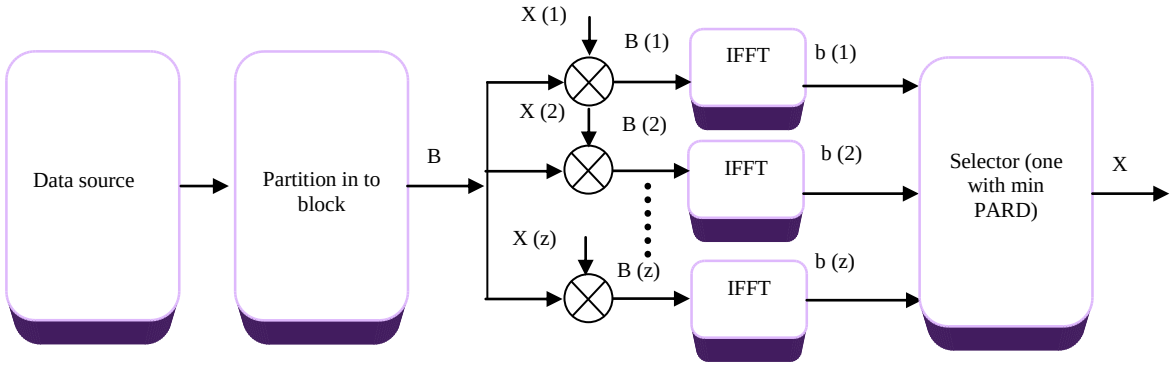


Fig. 2: SLM scheme

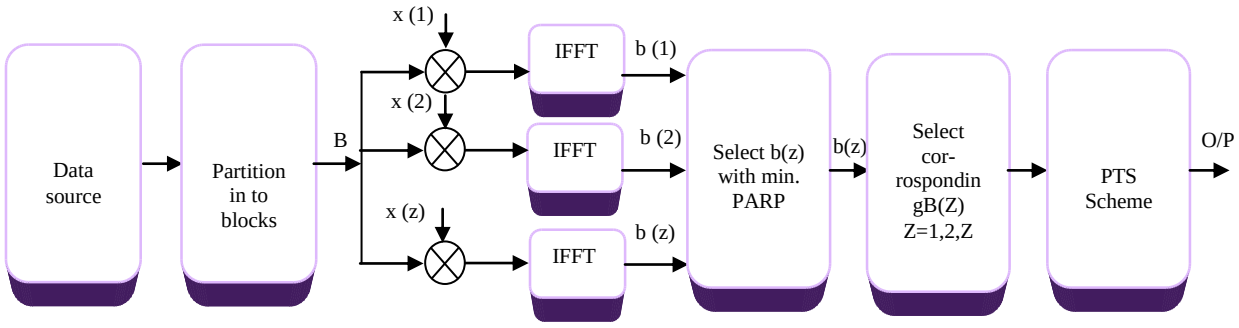


Fig 3: Block diagram of the proposed method

The selection of the phase factors is limited to a set with a finite number of elements to reduce the search complexity. PTS technique has exponentially increasing search complexity, and works with an arbitrary number of subcarriers and any modulation scheme. The phase factor is attained by employing Advanced Artificial Bee Colony Optimization Algorithm and Levy-Flight in AABC algorithm provides switching between different phase factors. The PTS algorithm can be described in following steps:

• Divide the OFDM sub-carriers into *M* disjoint sub blocks.
• Generate the OFDM signal for each sub-block by taking IFFT.
• Combine *M* output OFDM signals with weighting factors.
• The weighing factors are generated with Advanced Artificial Bee Colony optimization algorithm.

2.3 SLM technique

In SLM technique as shown in Fig2, from a single OFDM sequence *B* with a length of *N*, number of sequences are generated that represent the same information using some rotation factors and the sequence with lowest PAPR is transmitted. If the number of generated new sequences is *Z*, called the SLM length, then all these sequences are the result of multiplying the incoming original OFDM sequence *B* by *Z* different rotation factors. These factors are given in vector form as:

$$b^{(i)} = [b_0^{(i)}, b_0^{(i)}, ..., b_{N-1}^{(i)}] \quad (10)$$

where, i = 1 to Z and represents the indices of these factors and X is the rotation factor in vector form. After multiplying these factors by the original OFDM sequence B is :

$$B^{(i)} = b_0 x_0^{(i)}, b_1 x_1^{(i)}, b_2 x_2^{(i)}, b_3 x_3^{(i)} ....., b_{N-1} x_{N-1}^{(i)} \quad (11)$$

The multiplication factors are phase rotations selected appropriately such that multiplying a complex number by these factors results in rotation of that complex number to another complex number representing a different point in the constellation. Hence,

$$x_n^i = e^{-j\theta_n^i} \quad (12)$$

where $\theta_n^i \in [0,2\pi]$ and θ is the angle of rotation. The rotation vectors used as side information are transmitted for signal recovery. The efficiency of SLM approach depends on the amount of scrambling done by these rotation factors on the original OFDM sequence and the length of SLM *Z*. As number of SLM sequences, PAPR performance becomes better but at the expense of increase in system complexity. The SLM algorithm can be described in following steps.

• Multiply the input data signal with U different phase sequences.
• Generate the OFDM signal for each signal (*Z* signals).
• Select the OFDM signal with lowest PAPR.

Although SLM technique has moderate implementation complexity, this complexity increases as *Z* increases. For this reason, many researchers devoted their work in this field towards improving the complexity computation of conventional SLM.

A new scheme is proposed based on the SLM and PTS schemes, which offers better PAPR reduction performance than the all others three schemes. The proposed scheme is basically a combination of SLM and PTS schemes. In this scheme first SLM scheme is applied and the best combination of phase sequence and input data which give minimum PAPR. Now for further reduction of PAPR, this combination of phase sequence and input data to PTS scheme which further reduce the PAPR. The proposed scheme shown in fig 3 can be described in the following steps.

• Multiply the input data signal with *Z* different phase sequences.
• Generate the OFDM signal for each signal (Zsignals).
• Select the OFDM signal with lowest PAPR $B^{(u)}$
• Select corresponding combination of phase sequence and input data i.e. $B^{(u)}$.
• Apply $B^{(u)}$ as an input to PTS scheme.
• Obtain signal with reduced PAPR after applying the PTS scheme.

The working of the optimization can be explained in the steps below:

Step 1: Initialize the parameters, The ABC generates a randomly distributed initial population of finite solutions.

Let $X_m = \{x_{m,1}, x_{m,2}, ..., x_{m,z}\}$ represent m^{th} solution, where *z* is the dimension size, each employed bee generates new solution Q_i in the neighborhood of its present position as given below:

$$Q_{n,p} = X_{m,p} + \gamma_{m,p} \times (X_{n,p} - X_{m,p}) \quad (13)$$

Xm is randomly selected solution, *p* is random dimension index from $\{1,2.....n\}$ and $\gamma_{m,p}$ is the random number within [1,-1].

Step 2: criteria check, If the solution has attained acceptable level then criteria is fulfilled and best solution is occupied else updation of the parameters takes place in the next iteration and fitness is going to be evaluate till the criteria check meets.

Step 3: The random direction and distance for the search of food using osphresis by an individual fruit fly.

$$X_m = X_axies + 2 * rand() - 1 \quad (14)$$

$$Y_m = Y_axies + 2 * rand() - 1 \quad (15)$$

Since the food location cannot be known, the distance to the origin is thus estimated first distance, then the smell concentration judgment value (S) is calculated, and this value is the reciprocal of distance.*X* and *Y* are the co-odinates to find the location of the food source from the reference location, *rand()* is he random value given by the fruit fly algorithm.

Step 4: Updation :Once the new candidate solution Q_n is generated, a greedy selection is used. If the fitness value of $Q_n$is better than that of its parent then update X_n with Q_n; otherwise keep X_n unchanged.

If a position cannot be improved over a predefined number of cycles, then the food source is abandoned.Assume that the abandoned source is X_n,and then the scout bee discovers a new food source to be replaced with n^{th}as equation below:

$$X_{n,p} = lb_m + rand(0,1) \times (ub_m + lb_m) \quad (16)$$

rand(0,1) is a random number within [0,1] based on a normal distribution and *lb,ub,* are lower and upper boundaries of the n^{th}dimension, respectively.

Step 5: Check fitness repeatedly,An onlooker bee evaluates the nectar information taken from all employed bees and chooses a food source with a probability related to its nectar amount.

3. Results and Discussions

The new optimized Partial Transmit Sequence (PTS) scheme and SLM for PAPR reduction in MIMO-OFDM is intended. SLM and PTS scheme is based on combining the phase-shifted signal sub blocks as classical, both the techniques were clubbed to attain better throughput. The proposed and existing technique implemented in the working platform of the Matlab, throughputs and comparative study will be jotted down in this section to show the efficiency of the proposed technique. **Peak to average power ratio (PAPR):** The PAPR graph for the proposed and the existing techniques is given in figure 5 .

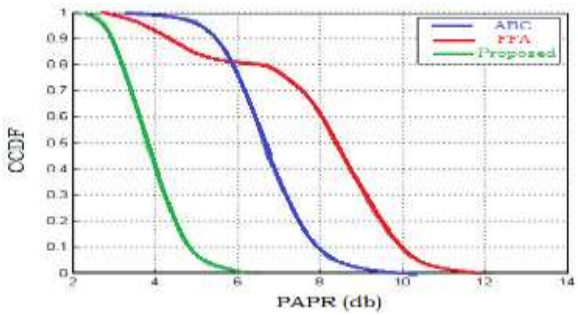


Fig.4: PAPR

Table 1:Comparison for ABC, FFA and Hybrid

Algorithms	PAPR (db)
ABC	9.9
FFA	11.9
Hybrid (ABC+FFA)	6

It can be noted from above figure that PAPR reduction takes place in every technique but for the proposed technique PAPR takes place in short period of time. Moreover, the PAPR is reduced to 5dB. The main motive of the work is to attain as less PAPR as possible, to improve the efficiency of the technique. The table 1 represents comparison of ABC,FFA and hybrid proposed algorithms.

Bit Error Ratio: The Bit Error Rate (BER) is the number of bit errors per unit time. The Bit Error Ratio (BER) is the number of bit errors divided by the total number of transferred bits during a studied time interval. BER is a unit less performance measure

often expressed as a percentage. The BER of the proposed and existing technique is depicted in figure below.

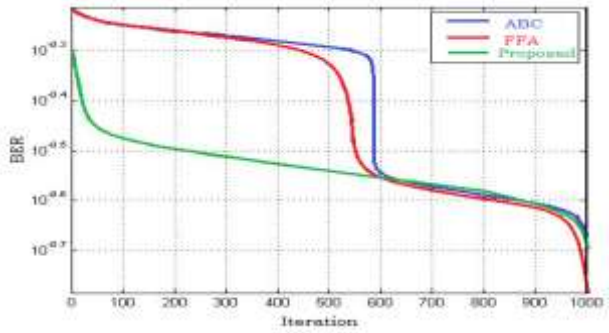


Fig. 5: Bit Error Ratio

It can be noted from the graph that the BER for the proposed technique is considerably lower than existing techniques. BER represents the output corrective level, hence the proposed technique is better in terms of BER.

Symbol Error Ratio: Symbol Error Ratio is related to the error occurred with transferred symbols. It is the ratio of total number of transferred symbols to the received error free symbols. The Symbol Error Ratio for the proposed and existing techniques is depicted in figure below.

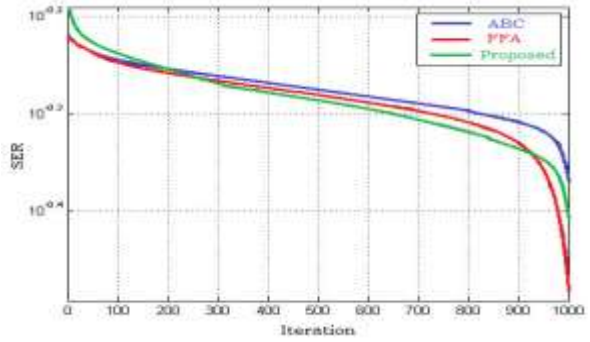


Fig. 6: Symbol Error Ratio

Table 2:Comparison analysis for ABC, FFA and Hybrid at 500 iterations

Algorithms	BER	SER
ABC	$10^{-0.29}$	$10^{-0.27}$
FFA	$10^{-0.3}$	$10^{-0.28}$
Hybrid(ABC+FFA)	$10^{-0.54}$	$10^{-0.29}$

It can be observed from above figure that Symbol Error Ratio for the proposed technique is decreasing considerably faster than existing techniques. Moreover proposed method showed better results than existing technique. Table 2 shows the comparison analysis at 500 iterations for ABC,FFA and Proposed algorithms.

4. Conclusions

The PTS and SLM techniques clubbed to reduce PAPR in MIMO-OFDM is implemented and results are arranged in above section. Noted that proposed technique performs better than existing techniques. Throughput is improved by implementing two techniques with proposed algorithm for phase factor. Proposed algorithm has played advantageous role for better performance. In future advanced technique can be employed to mitigate PAPR further, as it is always advantageous to have minimum noise level.

References

[1] Sheng-Ju Ku,"Low C omplexityPTS –Based Schemes for PAPR Reduction in SFBC MIMO-OFDM Systems"IEEE Transactions on broad casting ,vol.60,no.4,December2014.

[2] Mohamed A .Abbas,Safa Gasser , Ashraf M.AzizAand Mohamed E.Khedr "A NEW Approach for PAPR Reduction of OFDM Signal Based on SLM and PTS" ,ISBN:978-1-4799-3166-8 IEEE 2014.

[3] El Mouhib, Ahmed Oquour, YounesJabrane, BrahimAitEs Said and AbdellahAitOuahman, "PAPR Reduction Using BPSO/PTS and STBC in MIMO OFDM System", Journal of Computer Science, Vol. 7, No.4,pp. 454-458, 2011.

[4] MukunthanPandurangan and DananjayanPerumal, "Modified PTS with FECs for PAPR Reduction in MIMO OFDM System with Different Sub blocks and Subcarriers", IJCSI International Journal of Computer Science Issues, Vol. 8, Issue 4, No 2,pp.444-452,2011.

[5] Pankaj Kumar Sharma, Chhavi Sharma, S.K.Tomar and A.K.Gupta, "PAPR Reduction in MIMO-OFDM systems using new PTS", MIT international Journal of Electronics and Communication Engineering, Vol. 1, No. 2, pp.83-87,2011.

[6] Pawan Sharma and SeemaVerma, "PAPR Reduction of OFDM signals using selective mapping with turbo codes", International Journal of Wireless & Mobile Networks (IJWMN),Vol. 3, No. 4, pp.217-223,2011.

[7] NecmiTaspinar, DervisKaraboga, MahmutYildirim and BahriyeAkay, "PAPR reduction using artificial bee colony algorithm in OFDM systems", Turk Journal of Electrical Engineering & Computer Science, Vol.19, No.1, pp.,47-58, 2011.

[8] P.Malathi and P.T.Vanathi, "Peak to Average Power Ratio (PAPR) Reduction Techniques for OFDM-MIMO System",IJCSI International Journal of Computer Science Issues, Vol. 1, No.1, pp. ,92-96, 2011.

[9] Jenn-Kaie Lain, Shi-Yi Wu and Po-Hui Yang, "PAPR reduction of OFDM signals using PTS: a real-valued genetic approach", EURASIP Journal on Wireless Communications and Networking, Vol. 2011, No.126, pp.1-8, 2011.

[10] Eonpyo Hong and DongsooHar, "Peak-to-Average Power Ratio Reduction in OFDM Systems Using All-Pass Filters", IEEE Transactions on broadcasting, Vol. 56, No. 1, pp.114-119, 2010

[11] V.Vijayarangan and R.Sukanesh, "An overview of techniques for reducing Peak to Average Power Ratio and its selection criteria for Orthogonal Frequency Division Multiplexing radio systems", Journal of Theoretical and Applied Information Technology,Vol.5,No.5,pp.25-36, 2009..

[12] Ashraf A. Eltholth, Adel R. Mikhail, A. Elshirbini, Moawad I. Moawad and A. I. Abdelfattah, "Peak-to-Average Power Ratio Reduction in OFDM Systems using Huffman Coding", World Academy of Science Engineering and Technology Journal,Vol.43, pp.266 -270, 2008.