Implementation of Chicken Swarm Optimization (CSO) with Partial Transmit Sequences for the Reduction of PAPR in OFDM System

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Abstract—**Computational complexity considers as challenging issue in conventional Partial Transmit Sequence (PTS) scheme, even though it has good performance to reduce PAPR. In this paper, one of the recently developed bio-inspired algorithm named Chicken Swarm Optimization (CSO) is implemented with the combination of Partial Transmit Sequences to reduce PAPR, one of the most featured problems in OFDM system. Results show that CSO with PTS scheme reduces the computational complexity and improves the reduction of PAPR up to 2.25 dB at 0.0011 complementary cumulative distribution function (CCDF) for an unmodified OFDM signal.**

Keywords-bio-inspired algorithm; CSO; partial transmit sequence; peak to average power ratio; computational complexity

I. INTRODUCTION

To maintain the increasing demand of high data traffic in communication systems, OFDM considers as one of the most implemented technologies [1]. It is already a part of the physical layer of LTE, WIMAX, IEEE 802.11a and 802.11g [2]. In communication systems, multicarrier technology like OFDM deals with a huge number of subcarriers. When subcarriers are not spaced properly i.e. exception of orthogonality, all of these signals add at a point and cause the signal to peak high counts as high peak to average power ratio or PAPR at the transmitters. High PAPR leads towards non-linear distortion, spectral spreading and increases the cost of the power amplifier. Hence to reduce PAPR, several technologies have been used such as clipping, companding, SLM, PTS, Interleaving, Tone Injection, Tone rejection, ACE, CCS, LBC [3]. Computational complexity remains a challenging issue for all the techniques except clipping and companding [4]. Several algorithms and methods have been used with these techniques such as combinatorial optimization algorithms, quantum-inspired evolutionary algorithm (QEA), a gradient descent search etc. But, most of them having the problem with the performance of PAPR reduction. In recent phase, researchers are trying to improve the performance of bio-inspired algorithm due to the simplicity and very effective optimization characteristics of nature inspired algorithms. Several bio-inspired algorithm exists like PSO, CSO, CS, BA, GA and so on [5].Until now, researchers successfully used swarm intelligence to reduce PAPR with PTS such as the Artificial Bee Colony Algorithm, Parallel Tabu Search Algorithm, Cuckoo Search Optimization, Frog Leaping Algorithm Genetic-Simulated Annealing etc. where most of them having a problem finding an optimum value. In this paper, a new bio-inspired algorithm named Chicken Swarm Optimization (CSO) (which is developed by Xian-Bing Meng et al in 2014) with PTS system is implemented to reduce PAPR. CSO is an algorithm that is developed based on mimicking the hierarchical order and behavior of chicken swarm. As it has better performance over BA (Bat Algorithm), PSO (Particle Swarm Optimization), DE (Differential Evolution) [6], it helps OFDM system to find less PAPR signals to transmit.

II. SYSTEM MODEL

The system model comprises of PTS and CSO algorithm. In this section, at first PTS technique and later CSO and the combination of PTS-CSO is described to provide a better understanding of the proposed system model.

A. PTS

In PTS, QAM symbols partitioned into a number of sub-blocks. Later, through IFFT, the time domain is created for the transmitting signals. The IFFT is used as a modulator bank because huge modulator is not convenient for the system. Each IFFT signals are weighted by a set of phase. The combination of IFFT signals and weighted phase gives minimum PAPR signals to transmit. Suppose, symbols stream=[$X1, X2, X3, \ldots\ldots X_N$] partitioned into a number of K sub-block which could be written as follows:

$$X = \sum_{K=1}^{K} X_K \tag{1}$$

Above, the sub-blocks X_K consist of set of sub-carriers of same size N. The time domain signal after IFFT is represented by

$$x = IFFT\{\sum_{K=1}^{K} X_K\} = \sum_{K=1}^{K} X_K \tag{2}$$

In order to minimize PAPR, a combination of x signals and rotational phase vector b = [$b1, b2, b3... b_K$] is formulated, which denoted by

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$$x(b)=\sum_{k=1}^{K} b_K X_K \quad (3)$$

Multiplication of properly shifted phase b_K and X_K reduces the peak power of x (b) signal. Let X_K is multiplied by $b_K = e^{j\theta_K}$, where θ_K can remain within [$0,2\pi$], denoted by

$$x(b)=\sum_{K=1}^{K} e^{j\theta_K} X_K \quad (4)$$

Where $,\theta=[\theta_1,\theta_2,\theta_3,......,\theta_K]$ .By Equation (4), rotational phase vector will be found to reduce PAPR of the system.

B. CSO

Chicken Swarm Optimization represents the behavior of chicken swarm, including roosters, hens, chicks to optimize the computational problem's solution. In other words, it could be said that it extracts the hierarchal characteristic of chickens to optimize the problem. CSO is designed by following rules: [6]

- There are several gatherings in a chicken swarm. Each gathering contains a predominant rooster, two or three hens, chickens, and chicks.
- To create the hierarchal order within a gathering, fitness value considers as the performance metrics and based on that personality of the chicken are decided. Roosters will be selected as per the fitness value of chickens. Others will be divided as hens, chicken and chicks according to their fitness value. A random mother-child relationship between the hens and the chicks will be set.
- Relationship such as hierarchal order, strength relationship and mother-chicks in a gathering will remain constant. Statuses will upgrade each few (G) time steps.
- For searching the food, rooster in a group is followed by the chickens of that group. Roosters and dominant hens would have the access to food at first which could be found randomly by other hens or chicken. The chicks look around their mother (hen) for searching the food. The dominant one has the advantage in a rivalry for food.
- The number of the roosters, the hens, the chicks and the mother hens are denoted by RN, HN, CN, and MN. Roosters and chicks are decided by the best RN chickens and worst CN ones and others are considered as hens.

C. PTS-CSO

For the PTS-CSO system, a baseband system with 1000 symbols/carrier is considered. Available number of subcarrier is 512 and 1024 consecutively and number of available sub-block is 2,4,8,16,32,64,128,256,512,1024. The modulation with sub-carrier is done through IFFT blocks. After that, a phase optimization has been done to get minimum PAPR with CSO algorithm. For that, a function is developed that can optimize with the help of CSO frame work. The framework of CSO follows following steps;

- Initialization
- Evaluation
- Defining fitness value at t=0.
- Update the solutions using following equations.

$$x^{t+1}{}_{i,j}=x^{t}{}_{i,j}*(1+Randn(0,\sigma^2)) \quad (5)$$

$$x^{t+1}{}_{i,j}=x_{i,j}{}^{t}+S1*Rand*(x^{t}{}_{r1,j}-x^{t}{}_{i,j})+S2*Rand*(x^{t}{}_{r2,j}-x^{t}{}_{i,j}) \quad (6)$$

$$x^{t+1}{}_{i,j}=x^{t}{}_{i,j}+FL*(x^{t}{}_{m,j}-x^{t}{}_{i,j}) \quad (7)$$

Parameter of CSO function such as fitFunc, Pt,M (maximum iteration), pop (population size),dim(dimension), G (number of updates), rPercent (population size of rooster), hPercent (population size of hen), mPercent (population size of mother chicken) optimize the value of PAPR reduction in the system. For the analysis number of M, Pop, dim are fixed and G, rPercent, hPercent, mPercent are varied. Simulation parameter, block diagram and flow chart of system model is illustrated below with Table I, Fig. 1 and Fig. 2.

TABLE I. SIMULATION PARAMETER

Parameter Name	Value
Available sub-carrier	512,1024
Available sub-blocks	2,4,8,16,32,64,128,264,512,1024
Constellation size	16-QAM
Oversampling factor	4
Symbol per carrier	1000
Number of generations, M	30
Population size, pop	20
Dimension size, dim	2
Number of updates, G	5,10,20
rPercent	0.2,0.3,0.15
hPercent	0.7,0.3,0.7
mPercent	0.5,0.3,0.5

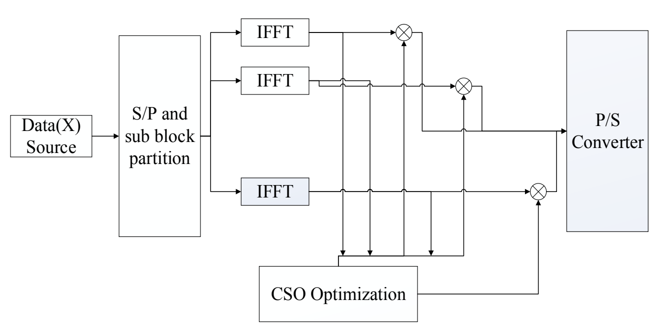

Figure 1. Block Diagram of PTS-CSO model.

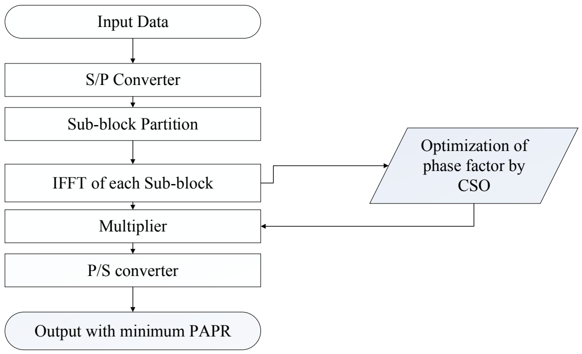

Figure 2. Flow Chart of PTS-CSO model.

III. Results and Discussion

In this section, the results of simulations are showed and discussed. Implementation is done with 512 and 1024 sub-carrier. Available sub-blocks for PTS system is 2,4,8,16,32,64,128,256,512,1024. For Chicken Swarm Optimization (CSO) we consider 3 cases of parameters.

Case-I: when the number of updates (G) is small, rPercent is less than hPercent and mPercent.
Case-II: when the number of updates (G) is medium and rPercent, hPercent and mParcent is equal.
Case-III: when the number of updates (G) is high and rPercent is higher than hPercent and mPercent.

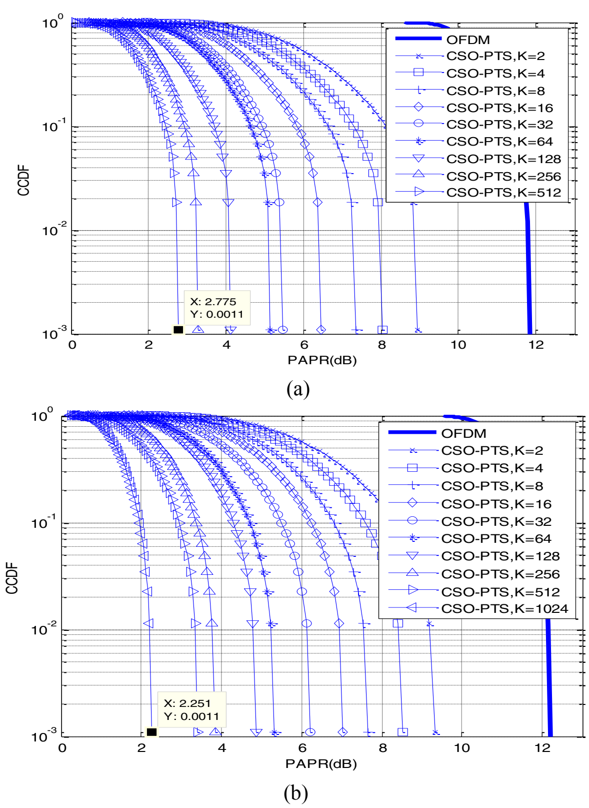

Figure 3. Simulation for ***Case-I*** with (a) 512 sub-carrier (b) 1024 sub-carrier.

The following Fig. 3 showed the result of ***Case-I***, where unmodified OFDM is 11.85 dB and 12.21 dB for 512 and 1024 sub-carriers. The effect of CSO-PTS optimization results 2.775dB and 2.251dB for highest available sub-block in each respective carriers. For 512 subcarrier and 1024 subcarrier, the improvement is 9.075dB and 9.959dB from the unmodified OFDM. The results of ***Case-I*** are listed below in Table II.

TABLE II. RESULT OF ***CASE-I***

Sub-block, K	Value of PAPR in dB for 512 sub-carrier	Value of PAPR in dB for 1024 sub-carrier
2	8.953	9.327
4	8.04	8.533
8	7.36	7.653
16	6.46	7.031
32	5.456	6.219
64	5.147	5.311
128	4.133	4.864
256	3.267	3.838
512	2.775	3.408
1024	------	2.251
OFDM	11.85	12.21

The following Fig. 4 showed the result of ***Case-II***, where unmodified OFDM for 0.011 CCDF is 11.92dB and 12.28dB for 512 and 1024 subcarriers. The effect of CSO-PTS optimization results reduction of PAPR value up to 2.635dB and 2.424dB for 0.011CCDF on 512 sub-carrier and 1024 sub-carrier for 0.011CCDF. The results of ***Case-II*** are listed below in Table III.

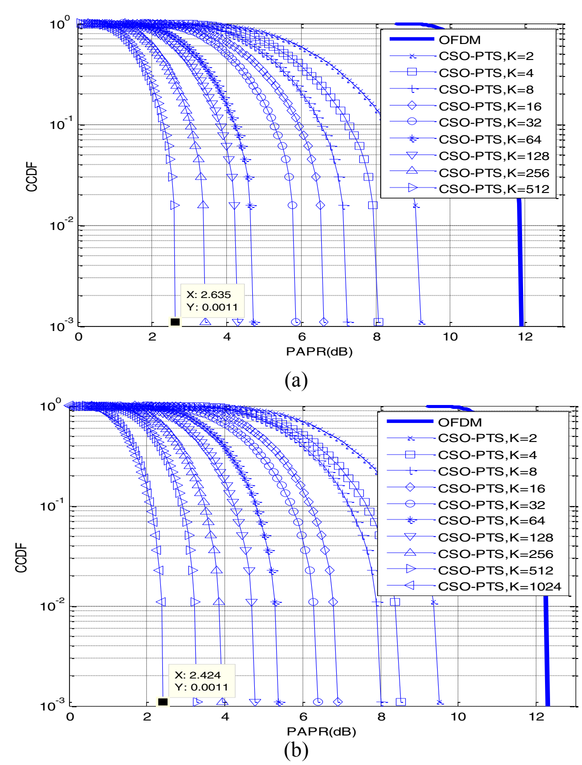

Figure 4. Simulation of ***Case-II*** with (a) 512 sub-carrier (b) 1024 sub-carrier.

TABLE III. RESULT OF ***CASE-II***

Sub-block, K	Value of PAPR in dB for 512 sub-carrier	Value of PAPR in dB for 1024 sub-carrier
2	9.196	9.503
4	8.063	8.511
8	7.224	8.012
16	6.615	6.899
32	5.861	6.391
64	4.717	5.373
128	4.292	4.78
256	3.432	3.926
512	2.635	3.289
1024	------	2.424
OFDM	11.92	9.856

The following Fig. 5 showed the result of ***Case-III***, where unmodified OFDM for 0.011CCDF is 11.93dB and 12.24dB respectively for 512 and 1024 sub-carriers. The effect of CSO-PTS optimization results in reduction of PAPR value up to 2.75dB and 2.308dB for 512 and 1024 sub-carrier. The improvement is 9.18dB and 9.93dB for 512 and 1024 sub-carriers. The results of ***Case-III*** are listed below in TABLE IV.

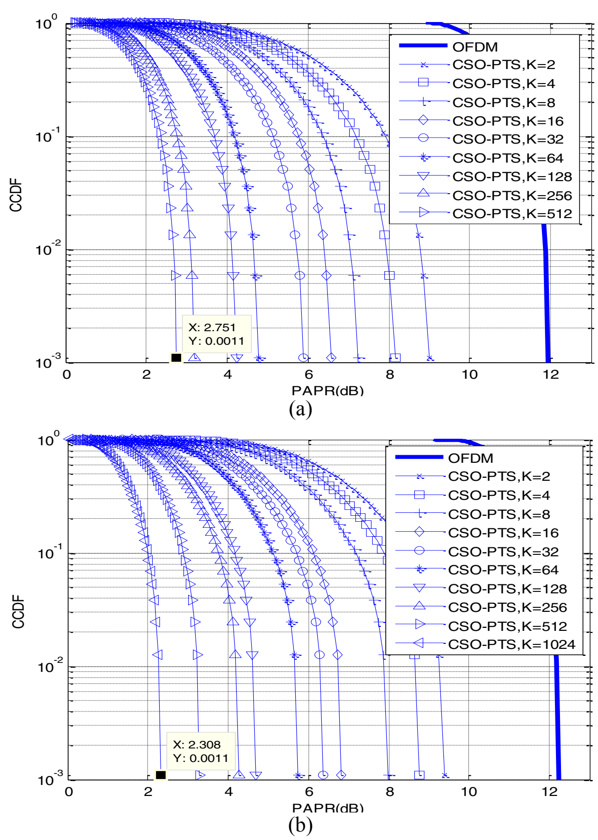

Figure 5. Simulation of ***Case-III*** with (a) 512 sub-carrier (b) 1024 sub-carrier.

TABLE IV. RESULT OF ***CASE-III***

Sub-block, K	Value of PAPR in dB for 512 sub-carrier	Value of PAPR in dB for 1024 sub-carrier
2	9.001	9.382
4	8.153	8.769
8	7.23	7.996
16	6.564	6.829
32	5.882	6.379
64	4.776	5.739
128	4.232	4.689
256	3.192	4.261
512	2.75	3.274
1024	------	2.308
OFDM	11.93	12.24

In all cases, the parameter of CSO such as iteration, population and dimension are considered 30, 20 and 2.The reduction of PAPR for 512 carrier is found highest 9.285dB when rPercent, hPercent, nPercent chicken were same. On the other hand, the reduction of PAPR for 1024 sub-carrier is found highest 9.959dB when rPercent is less than hpercent and mPercent with 5 updates(G).We consider value the of G [2,20] as mentioned in [6]. At CCDF 0.001 with 16 sub-block PAPR is found 9dB (approx.) in [7] for 512 sub-carrier whereas with CSO-PTS it is found 7dB (approx.) in this experiment. So with 2^16=65536 searches with PTS, Chicken swarm Optimization is showing more effectiveness than Cuckoo Search Algorithm to reduce PAPR in dB, which shows the efficiency of CSO-PTS over other existing bio inspired-PTS algorithm. All the simulations in the paper were done with MATLAB software.

IV. CONCLUSION

In this paper, to reduce PAPR in OFDM system, a new technique has been implemented which comprises conventional PTS and a new bio-inspired algorithm named Chicken Swarm Optimization (CSO).The analysis has done with varying the parameters of CSO algorithm through three different cases. In each case, the simulation has shown a huge margin of improvement for the reduction of PAPR which is up to 2.25 in dB at 0.0011 CCDF for an unmodified OFDM signal. Here from the simulation, it can be observed that the more number of sub-carrier increase, the more reduction of PAPR achieved, hence the proposed technique is also usable for high data system which comprises 2048,4096 sub-carrier as well and also other techniques like MIMO-OFDM.

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