Partial Transmit Sequence Technique Based on Multi-objective Bat Algorithm for PAPR Reduction in OFDM

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***Abstract*— With the advancement in communication field and its increasing demands, there should be high data rate in addition to both power efficiency and lower bit rate. In Multi-carrier Modulation (MCM) such as orthogonal frequency division multiplexing (OFDM), the data stream, to be transmitted, is divided into several lower rate data streams. OFDM signals have a problem of high peak to average power ratio (PAPR). Several techniques have been executed to improve the PAPR while partial transmit sequence (PTS) technique provides a successful reduction in PAPR, but it may increase the computational complexity. In this paper an efficient technique i.e. Partial Transmit Sequence based Multi-objective Bat Algorithm (MOBA-PTS) has been presented. The simulation result of the proposed algorithm has effective method for reducing PAPR and computationally complexity.**

Keywords*— Orthogonal Frequency Division Modulation (OFDM); Peak to average power ratio (PAPR); Partial transmits sequence (PTS); Multi-objective bat algorithm (MOBA).

I. INTRODUCTION

Multi-carrier modulation is the technique for data transmission which has lot of properties such as robustness. Recently, Orthogonal Frequency Division Multiplexing (OFDM) is the mostly generally utilize technique for MCM. OFDM has very popular for data transmission with high data rate. The OFDM has major problem of large envelope fluctuation which is recognized as Peak to Average Power Ratio (PAPR). At the transmitter side, the power amplifier is used so that the operating point is lying in linear region. But due to large fluctuations, operating point lies out of region. Several algorithms are developed for reducing PAPR [3]. OFDM is a most popular technology of communication system, which has many important applications like Wireless Local Area Networks (WLAN), European Telecommunication Standard Institute (ETSI) and High Performance Radio Local Area Network (HIPERLAN) [8].

The whole signal frequency band is separated into non-overlapping frequency sub-channels in the traditional parallel data system. The N sub-channels are modulated with a split symbol. This frequency multiplexed sub-channels are high-quality to abolish the inter-channel interference. It has one weakness of wasteful use of the obtainable spectrum. The parallel data and FDM has used to avoid elevated speed equalization, impulsive noise and multi-path distortion. For entirely use of bandwidth, it can take a signaling rate b is spaced b apart. The dissimilarity among the conventional non-overlapping multi-carrier modulation technique and the overlapping multi-carrier modulation technique is shown in figure 1.3. The oversampling technique is essential to condense crosstalk involving subcarrier so that it can save 50% bandwidth and for this, the orthogonality is maintained in subcarrier. The sidebands of the creature carriers have overlapped for the understanding of carrier in an OFDM signal. The carrier must be exactly orthogonal so that the received signal has no adjacent carrier interference [9].
The paper is prearranged as follows: Section I, presents brief introduction about OFDM. Section II, introduces about partial transmit sequence technique. Section III, describes multi-objective bat algorithm. Section IV, includes the simulation results. Section V, concludes the results of work.

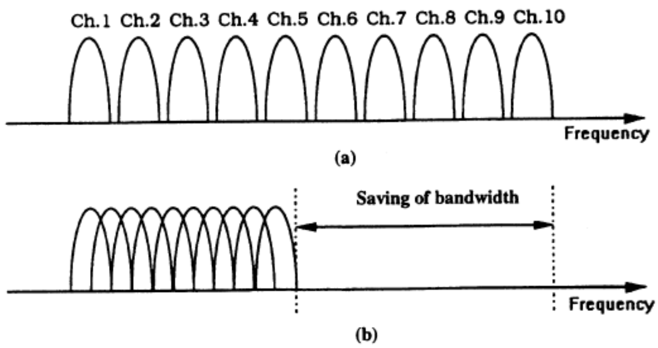

Figure 1 Concept of OFDM signal, (a) Conventional Multi-carrier technique (b) Orthogonal multi-carrier modulation technique [9]

II. PEAK TO AVERAGE POWER RATIO

In OFDM system, the peak value of the system can be very elevated as evaluate to the average of the entire system due to occurrence of large number of independently modulated sub-carriers. PAPR is defined as the ratio of peak to average power value.
OFDM signal may be create by an N point IFFT at the transmitter, and FFT is operational at the receiver. Let us describe a complex input data of N sub-carrier as X = $\{X_0, X_{1,\ldots\ldots\ldots\ldots,}X_{N-1}\}^T$ is created and with each sub carrier has orthogonal. T symbolize one of the sub-carriers$\{f_n, n = 0,1, \ldots \ldots . N-1\}$, where nΔf = 1/NT and NT is the duration of OFDM data block X. The discrete OFDM symbol can be written as [2]:

$$x(t) = \frac{1}{\sqrt{N}} \sum_{k=0}^{N-1} X_n e^{j2\pi\Delta f t}, \qquad 0 \le t \le NT$$

The PAPR of transmitted signal is defined as [2]:

$$\text{PAPR} = \frac{\max_{0 \le t < NT} |x(t)|^2}{\frac{1}{NT}\int_0^{NT} |x(t)|^2 dt}$$

III. PARTIAL TRANSMIT SEQUENCE

The Partial Transmit Sequence is the most attractive scheme for reducing PAPR in OFDM. The computational complexity is enlarged as the number of sub-blocks increased [5]. In 1997, Muller and Huber have projected a PTS technique which is adapted of Selection mapping. The standard of the technique can define as the organization of suitably phase rotated signal to diminish the peak power of the multiplex signal. The block diagram of PTS is shown in figure 4.1. In OFDM transmission, the incoming bit stream is rehabilitated to a parallel block of data. The parallel block of data is separated into sub-blocks. The lengths of sub-blocks are similar as the parallel block of data. Then, the sub-blocks are concurrently approved through Inverse Fast Fourier Transform. The IFFT create a parallel transmission sequence. After IFFT, the PTS is rotated by a phase factor. The output of phase factor is the candidate signal. The dissimilar combinations of phase factors are performing to get large number of candidate signals. Ultimately, the least one PAPR has selected. The PTS has high computational complexity [4]. The particle swarm optimization (PSO) algorithm for suboptimal partial transmit sequence (PTS) is obtainable for the low computation complexity and the decrease of the PAPR of an OFDM [7]. The conventional PTS can provide good PAPR reduction but at the cost of exhaustive search which results in high complexity. The Cross-Entropy (CE) Method is used to reduce both the PAPR and the complexity [6].

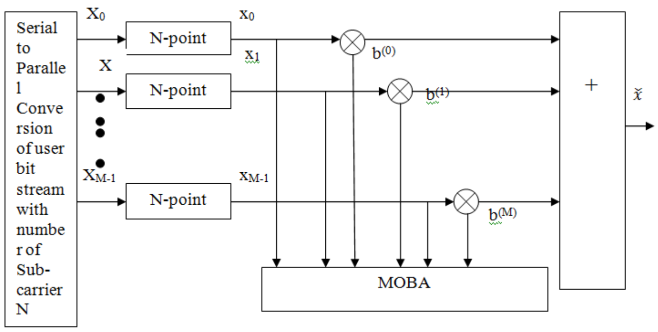

Figure 2 Partial Transmit Sequence

IV. MULTI-OBJECTIVE BAT ALGORITHM

The In 2010, Xin She Yang has developed the bat algorithm. The bat algorithm is bio-inspired computation for resolve non-linear and global optimization problems. According to Xin She Yang, the bat algorithm has three main idealized rules:

- All bats recognize the dissimilarity between food and background barriers. The bats use echolocation to intelligence distance in some magical way.
- All bats fly with frequency f_{min}, with velocity v_i and at position x_i. To search the food, they can vary wavelength λ and loudness A_0. Depending upon target, they can regulate the wavelength and rate of pulse emission r ε [0, 1].
- They can fluctuate loudness in many ways. They diverge of loudness from large A_0 to minimize A_{min}.

The pseudo code of MOBA ban be abridged as figure 3

Objective functions $f_1(x), \dots \dots \dots \dots \dots f_K(x), \quad x = (x_1, \dots \dots \dots . . x_d)^T$
Initialize the bat algorithm x_i $(1, 2, \dots \dots \dots \dots ., n)$ *and* v_i
For j = 1 to N (points on pareto fronts)
Generate K weights $w_k \ge 0$ *so that* $\sum_{k=1}^{K} w_k = 1$
From a single objective $f = \sum_{k=1}^{K} w_k f_k$
While $(t < Max\ number\ of\ iterations)$
Generate new solutions and update
If $(rand > r_i)$
Random walk around a selection best solution
End if
Generate a new solution by fly randomly
If $(rand < A_i$ *and* $f(x_i) < f(x_*))$
Accept the new solutions
And r_i *increase and decrease* A_i
End if
Rank the bats and find the current best x_*
End while
Record x_* *as a dominated solution*
End
Post process results and visualization

Figure 3 Multi-objective bat algorithms

The combination of weighted sum and all objectives f_k for simplicity case as express as:

$$f = \sum_{k=1}^{K} w_k f_k, \qquad \sum_{k=1}^{K} w_k = 1$$

The correlation of *PF* can be possible to very weight with sufficient diversity. And weights are random vector drawn from a uniform distribution [10].

V. SIMULATION RESULTS

A. Parameters Setting for Matlab Simulation

The parameter name and description used for MATLAB simulation of the system model given following table I.

TABLE I. PARAMETER SETTING FOR SIMULATION

PARAMETERS	DESCRIPTION	VALUE
Sub-blocks	Sub-block size	2,4,8,16
N	Number of sub-carriers	128,256,512
L	Oversampling Factor	4
M	Constellation	16-QAM
M	Bits/Symbols	$log_2(M)$
PAPRdB	PAPR in dB	4 to 11
fitnessFunc	Fitness Function	10*log10(peak_power./mean_power)
Numofbats	Number of Bats	10
N_Iter	Maximum Iteration	5
A	Loudness	0.25
R	Pulse Rate	0.5

B. System Performance (CCDF Vs PAPR)

The figure 4 to 6 are ccdf vs PAPR performance of the partial transmit sequence with multi-objective bat algorithm. In the simulation, the parameters setting for PTS and MOBA are given table 5.1. The OFDM system has sub-blocks V(2,4,8,16) and employed QAM modulation. The oversampling factor of the transmitted signal was L=4. In each simulation the number of sub-carriers N(128,256,512) are different. In the PTS the number of the phase factor was selected as W=2 and the phase factors became $b_v = \pm 1$.

Figure 4 exemplify the PAPR reduction concert for essential original OFDM and MOBA-PTS. In this simulation, the sub-carrier N=128 with 16-QAM modulation used. The PAPR of the original OFDM signal was 10.4db when $Pr(PAPR(x)>PAPR_0) = 10^{-3}$. The PAPR of the system with sub-blocks 2, 4, 8 and 16 were 9.8dB, 8.9dB, 7.4dB and 6.1dB, respectively. It can be perceive that by escalating the number of sub-blocks PAPR reduces radically.

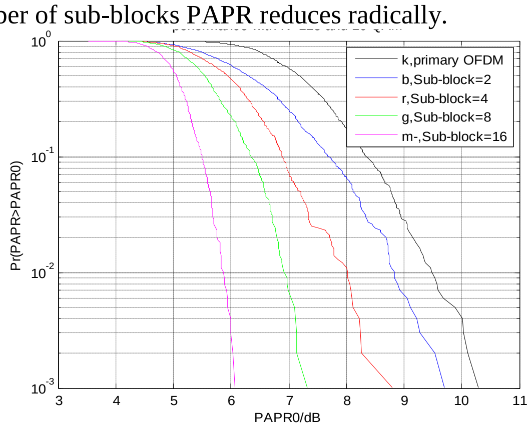

Figure 4. System Performance with Sub-carrier N=128 and 16 QAM

Figure 5 display the PAPR reduction feat for principal original OFDM and MOBA-PTS with N=256. The PAPR of the original OFDM signal was 11.2db when $Pr(PAPR(x)>PAPR_0) = 10^{-3}$. The PAPR of the system with sub-blocks 2, 4, 8 and 16 were 9.9dB, 9.1dB, 7.4dB and 6.7dB, respectively. It can be distinguish that as the number of sub-carriers raise the peak to average power ratio condense. Figure 6 point up the PAPR reduction show for primary original OFDM and MOBA-PTS. In this simulation, the sub-carrier N=512 with 16-QAM modulation used. The PAPR of the original OFDM signal was 10.7db when $Pr(PAPR(x)>PAPR_0) = 10^{-3}$. The PAPR of the system with sub-blocks 2, 4, 8 and 16 were 10.3dB, 9.6dB, 8.4dB and 7.1dB, in that order. It can be make out that by mounting the number of sub-blocks PAPR reduces drastically.

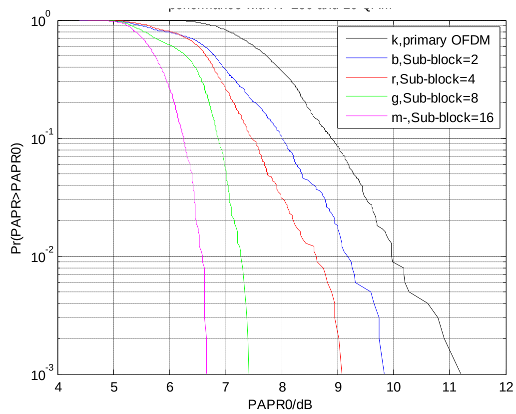

Figure 5. System Performance with Sub-carrier N =256 and 16 QAM

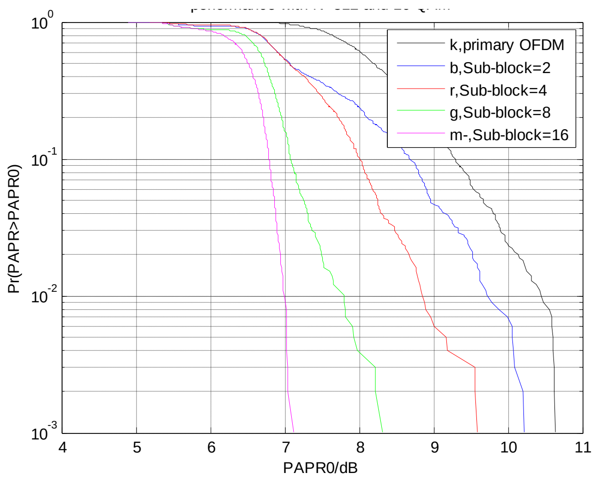

Figure 6. System Performance with Sub-carrier N =512 and 16 QAM

C. Comparison Between Moba And Firefly Algorithm

The relationship flanked by the MOBA and reference paper firefly algorithm is complete recognized in figure 7.

Common parameters:

- Number of sub-blocks = 16
- Number of sub-carriers = 128, 256
- Oversampling factor = 4
- Modulation = 16-QAM
- Fitness Function = 10*log10(peak_power./mean_power)

MOBA parameters:

- Number of bats = 10
- Maximum Iterations = 5

Firefly Algorithm parameters:

- Number of fireflies = 10
- Maximum Iterations = 5

Figure 7 explain the contrast of PAPR reduction routine for essential original OFDM and MOBA-PTS and Firefly algorithm PTS [1] with N=128. The PAPR of the original OFDM signal was 10.1db when $Pr(PAPR(x)>PAPR_0) = 10^{-3}$. The PAPR of the firefly algorithm PTS and multi-objective bat PTS with sub-block 16 were 7.0dB [1] and 6.1dB in that order. It can be perceive that the PAPR of multi-objective bat PTS reduces 0.9dB as match up to firefly algorithm PTS.

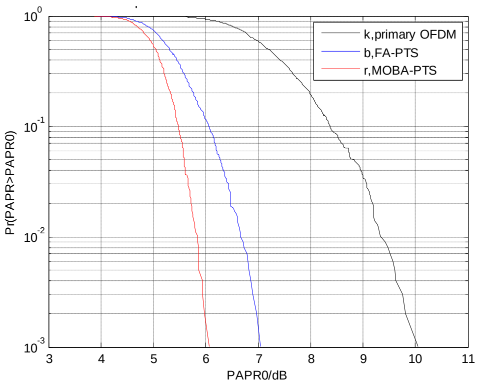

Figure 7. Comparison between Multi-objective Bat Algorithm and Firefly Algorithm with N=128

VI. CONCLUSION

PTS technique has delivered a very good PAPR reduction performance. It has high computationally complexity. In this paper, the proposed MOBA-PTS has analyzed for reducing the computationally complexity of the PTS and also reduce PAPR. The simulation results that as the enlarge number of sub-blocks, the PAPR reducing correspondingly. The computational complexity of the MOBA-PTS is dependent upon population size and max-generation i.e. 10*5=50, which is very less than the complexity of PTS W^V i.e. 2^{16-1} = 32768. The simulation results show that the MOBA-PTS has provided almost the same searches as that of the firefly PTS algorithm. The computationally complexity of MOBA-PTS and Firefly PTS is same but the proposed algorithm has more reducing PAPR than Firefly PTS. The difference of the PAPR was 0.9 between MOBA-PTS and firefly PTS.

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REFERENCES

1. Aman Dhillon, "PAPR Reduction in Multicarriers Modulation using Firefly Algorithm," International Journal of Innovative Research in computer and communication engineering, vol. 1, issue 5, july 2013.
2. Abhishek Arun Dash "OFDM Systems and PAPR Reduction Techniques in OFDM Systems", Bachelor Thesis, Department Of Electronics and Communication Engineering National Institute of Technology, Rourkela 2006 – 2010.
3. Himanshu Bhusan Mishra, "PAPR Reduction of OFDM Signals Using Selected Mapping Technique" Department of Electronics and Communication Engineering, National Institute of Technology Rourkela, 2012.
4. Ishita Gupta, "Implementation of a Single IFFT Block based Partial Transmit Sequence Technique for PAPR Reduction in OFDM" Master Thesis, Department of Electronics and Communication Engineering, National Institute of Technology Rourkela, May 2013.
5. Jun Hou, Jianhua Ge, and Jing Li, "Peak-to-Average Power Ratio Reduction of OFDM Signals Using PTS Scheme With Low Computational Complexity" IEEE Transactions on Broadcasting, Volume 57, No. 1, March 2011.
6. Jung-Chieh Chen, "Partial Transmit Sequences for Peak-to-Average Power Ratio Reduction of OFDM Signals With the Cross-Entropy Method," IEEE Signal Processing Letters, Vol. 16, No. 6, June 2009.
7. Jyh-Horng Wen, Shu-Hong Lee, Yung-Fa Huang, and Ho-Lung Hung, "A Suboptimal PTS Algorithm Based on Particle Swarm Optimization Technique for PAPR Reduction in OFDM Systems" Hindawi Publishing Corporation: EURASIP Journal on Wireless Communications and Networking, pages 8, 2008.
8. V.Vijayarangan, Dr.(Mrs.)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, Year 2005-2009, vol. 5, No. 5.
9. Van Lee, Richard and Prashad, Ramjee, "OFDM for Wireless Multimedia Communications" Boston: Artech House Publishers, pp. 260, 2000.
10. Xin-She Yang, "Bat Algorithm for Multi-objective Optimisation" Department of Engineering, University of Cambridge, 29 March 2012.