International Journal of Communication and Networking System
Volume: 05, Issue: 01, June 2016, Pages: 52-55
ISSN: 2278-2427

Evaluation of PTS based Algorithms for PAPR Reduction Techniques in OFDM System

U. Maheswaran , A. Karunakaran, M. Vengadapathiraj
Assistant Professor, Department of Electronics & Communication Engineering, Rajalakshmi Institute of Technology, Chennai

Abstract - In recent days, Orthogonal Frequency Division Multiplexing technique plays an important position in wireless digital communication system. OFDM technique is a Multicarrier Modulation method in which high capacity data is transmitted over a single communication channel. The biggest problem in this technique is that it results in high Peak –to- Average Power Ratio (PAPR), due to the usage of several sub carriers for modulation. A Large PAPR distorts the transmitted signal, if the transmitter keeps nonlinear circuit components, which in turn increases the system complexity and reduces the efficiency. Several methods are deployed to condense the PAPR level and System complexity. To improve PAPR performance, a novel method called Partial Transmit Sequence (PTS), which is a distortion less technique, can be used. But when implementing PTS algorithms in OFDM systems, several iterations of IFFT operations are done, which increases computational complexity. A new algorithm to reduce the computational complexity in PTS based PAPR reduction methods in OFDM transmitters are discussed in this paper.

Keywords - Orthogonal Frequency Division Multiplexing (OFDM); Peak-to-average power ratio (PAPR) ;Partial transmits Sequence(PTS).

I. INTRODUCTION

A. Orthogonal Frequency Division Multiplexing (OFDM)

OFDM (Orthogonal Frequency Division Multiplexing) is a widely used in wireless & mobile communication system. OFDM is a Multicarrier Modulation technique in which high capacity data is transmitted over a single communication channel. An OFDM is a part of family of multicarrier modulation technology, which can many signals are transmitted at the same time over a single transmission path modulated by several subcarriers which are orthogonal to each other. The basic concept of OFDM system is that, a high bit rate data stream is transmitted into a lower bit rate of carriers. Among the sub-carriers, orthogonally maintained by the IFFT algorithm. Thus, an OFDM system produces a complex signal by multiplexing [3].The OFDM data is generated by taking input data into a serial to parallel converter. The Inverse Fast Fourier Transform (IFFT) can bring the required spectrum to time domain and provide the orthogonally among carriers. The Fast Fourier Transform (FFT) is the reverse process of IFFT. The FFT can convert the time domain signal to frequency spectrum and the function of FFT to find the original transmission waveform. The block diagram of OFDM Transceiver structure is shown in Figure1 [14]. OFDM has a number of attractive features like immunity to channel fading, flexibility, easy equalization, resistance to impulse interference and capacity to handle strong echoes etc...

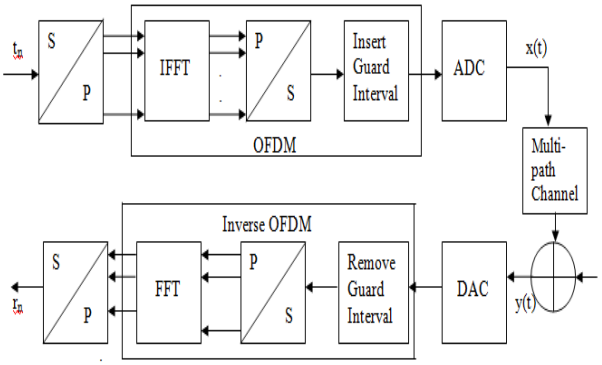

Fig.1 OFDM transceiver structure [14]

The OFDM is one of the very efficient techniques used in high speed digital broadband systems like Digital Television Broadcasting (DTB), Digital Audio Broadcasting (DAB) and Digital Video Broadcasting (DVB). OFDM is the most popular technology of communication system of recent days, which has many important applications like Wireless Local Area Networks (WLAN), European Telecommunication Standard Institute (ETSI) based protocols and High Performance Radio Local Area Network (HIPERLAN)[14].

B. Peak to Average Power Ratio (PAPR)

The peak-to-average power ratio (PAPR) is a parameter, which is obtained by taking the ratio of the peak amplitude of the signal squared (giving the peak power) and the RMS value of the signal squared (giving the average power). OFDM signal shows a very high Peak to average power ratio. A high PAPR can cause the complexity increased of the analog to digital converter (A/D) and digital to analog converter (D/A). Therefore, Radio frequency amplifier (RF) can decrease the efficiency and it can operate in non-linear region which damaging the performance of communication system. In OFDM system, an input data block of length N can be written as X = [X0, X1……,XN-1]T, and each symbol modulating one of a set of subcarrier, { fn , n = 0,1,……..,N-1}. The N subcarriers are selected to be orthogonal. The data block of the OFDM symbol is given by [1]:

$$x(t) = \left\{ \frac{1}{\sqrt{N}} \sum_{n=0}^{N-1} X_n e^{j2\pi n \Delta t} , \quad 0 \le t \le NT \right\}$$

PAPR of the OFDM signal is defined as the ratio between the maximum power and the average power during the OFDM signal [12]. Then the Peak to Average Power Ratio is expressed as [1]:

$$PAPR = \frac{\max: 0 \le t \le NT |x(t)|^2}{\frac{1}{NT}\int_0^{NT} |x(t)|^2 \, dt}$$

From the above it is apparent that the PAPR for an OFDM signal can be reduced by reducing the value of max |x (t)| [1]. OFDM signal with large Peak to Average Power Ratio is

International Journal of Communication and Networking System
Volume: 05, Issue: 01, June 2016, Pages: 52-55
ISSN: 2278-2427

given in figure 2. The PAPR problems are arising by calculation of four sinusoidal signals with different frequency and phase shift logically [12].

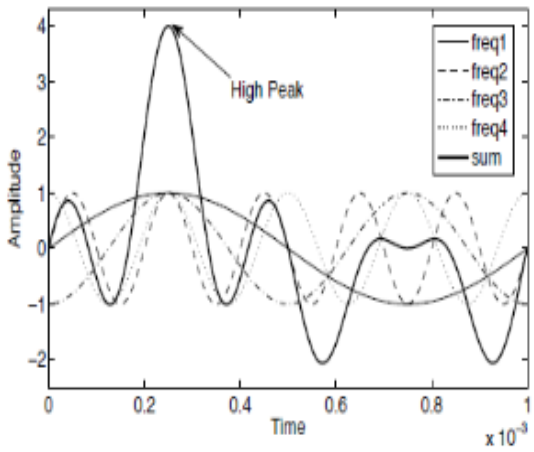

Fig. 2 High Peaks are obtained in OFDM Signals [12]

Another factor used in PAPR estimation and related techniques, is the Complementary Cumulative Distribution Function (CCDF), which is used to measure efficiency of PAPR technique[1].

The Crest Factor (CF) is defined as the square root of PAPR$CF = \sqrt{PAPR}$

And the CCDF for the signal is expressed as [7];

$$\boldsymbol{C}CDF = \max 0 \le t \le NT \ \frac{|x(t)|}{E|x(t)|}$$

Where E [|x (t)|] is the average power.

In several cases, the large PAPR can be decreased by reducing the value of maximum signal power for the reason that the large value of average power causes interference [7]. There are several techniques to reduce the PAPR of OFDM signals, which are basically divided into two groups such as signal scrambling techniques and signal distortion techniques. These can be further subdivided into many techniques such as clipping, peak windowing and peak cancellation. Other techniques under signal scrambling are block coding; sub-block mapping, selected mapping (SLM) and partial transmit sequence (PTS) [3].

C.Partial Transmits Sequence (Pts)

Partial Transmit Sequence is a distortion less technique based on scrambling rotations to group of subcarriers. PTS is based on the same principle as Selected Mapping (SLM), but gives better performance than SLM. The basic concept of PTS technique is the input data block is portioned into disjoint sub-blocks. The sub-carriers which are transmitted through the sub-blocks are multiplied by weighing value of the phase rotation vector for those sub- blocks. The phase rotation vector is chosen such that the PAPR value is minimized. The block diagram of PTS technique is shown in Fig. 3 [10]. In this, the serial data X is divided into sub sequence by a serial to parallel converter and are transmitted in sub blocks and each sub-blocks include N/V non-zero value [10].

The Partial Transmit Sequence method needs several inverse fast Fourier/wavelet transform (IFFT/IDWT) which results in large computational complexity. To decrease the system complexity, different algorithms which are based on PTS [13] are developed.

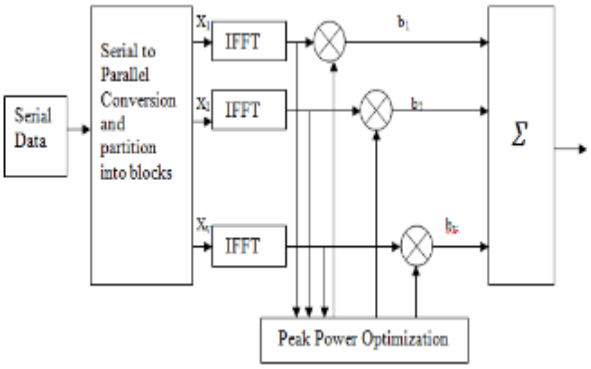

Fig. 3 Conventional OFDM generator based on PTS [10]

A. Particle Swarm Optimization(PSO)

PSO is a population-based global optimization technique which supported the social manners of bird flocking looking for food. The particle is called the population members which are mass-less and volume-less. All particles represent an explanation of high-dimensional space; its current position and its best position create by its region. The velocity update and position value has two primary operators of PSO technique. In the iteration, each particle repairs its position and velocity as follows [4]:

$$X_{k+1}^{i} = X_k^i + v_{k+1}^i$$
$$v_{k+1}^{i} = v_k^i + c_1 r_1 \left(P_k^i - X_k^i\right) + c_2 r_2 \left(P_k^g - X_k^i\right)$$

Where, X_k^i stand for Particle Position

v_k^i Correspond to particle velocity

p_k^i Represents Best "remembered" position

c_1, c_2 Stand for acceleration constants

r_1, r_2 Are random numbers between 0 and 1

The areas of application of PSO are edge detection in noisy images, signature verification, color image segment and QOS Ad-hoc multicast [4].

B. Artificial Bee Colony (ABC)

Artificial Bee Colony is the most successful swarm algorithm based on the behavior of the bees in nature.ABC algorithm is categorized into for aging and mating behavior. The employed bees, on lookers and scouts are three groups in the artificial bee colony to find the optimization problem [4]. In ABC algorithm, a food source position is corresponding to phase vector b_i =[b_{i1},b_{i2},….,$b_{i(v-1)}$],i=1,…..,S N, where S denotes the size of randomly distributed population size. For each employed bee, the new phase vector is expressed by [9]:

$$b_i = b_i + \emptyset_i (b_i - b_k)$$

Where I is a random number between [-1,1] ,b_k is a solution of the region of b_iThe fitness value of a solution b_i in the population is expressed as[9]:

$$fit(b_i) = \frac{1}{fit(b_i)}, \qquad if\ fit(b_i) \ge 0$$
$$= 1 + abs\left(fit(b_i)\right), \qquad if\ fit(b_i) = 0$$

Where, fit (b_i) stand for the PAPR value and is preferred to be a smallest amount [9].

International Journal of Communication and Networking System
Volume: 05, Issue: 01, June 2016, Pages: 52-55
ISSN: 2278-2427

C. Genetic Algorithm (GA)

GA is an Evolutionary Algorithm which is based on stochastic optimization algorithm.[4] GA initiate with random set of solution called population and which a population of string scan solution of optimization problems.

GA involves three principles:

- Selection
- Crossover
- Mutation

GA is valuable and well-organized when the search space is huge multipart, no mathematical investigation is obtainable and conventional investigate method be unsuccessful. But genetic algorithm has some weakness such as it is difficult to working on active data sets and not fit for explaining the restriction optimization problems [4].GA provides one more solution to reduce the complexity of PTS. It can useful with highly nonlinear problems and non-differentiable function. GA agrees to find the numerical solution to complex problems [8].

D. Differential Evolution (DE)

Differential Evolution is a population-based stochastic parallel swarm evolutionary algorithm. It is used to look for an optimal solution and reducing nonlinear, non differential and maintain space function. The differential evolution method usually four stages: initialization of the parameter vectors, mutation and difference vectors, cross over and selection [5].The differential method starts with an initial solution set, searches for a global optimum point from the feasible region. After initialization, the mutation operation of differential evolution creates donor vector to each population member. While doing the mutation, it uses three vectors. The first represents the local best, the second global best which are adaptive in nature and the third selected randomly.Once the mutation is complete, the crossover comes into play after generating the donor vectors. The function of cross over that it generates the final off spring vector. Cross over is a symbol of a characteristic case of "gene" replace.The next step of the algorithm is selection, which determines the population of next generation. It is the best solution of determine the new generation and thus cost function decrease with number of generation [5].It is similar to Genetic Algorithm, but there will be one difference. The genetic algorithm, mutation is result of small perturbations while differential evolution, mutation is result of arithmetic combination. DE has many benefits like simple to implement, reliable, accurate, robust and high-speed optimization.DE has used to discover the optimal solution but this process has a time consuming [4].

E. Ant Colony Optimization (ACO)

ACO is based on Swarm Intelligence of meta-heuristic motivated by the for aging manners of ant sin the natural. The inspiring source of ACO is the pheromone trail laying which resembles the behavior of ant colony for search shortest path. It means that if the pheromone trail is high then searching the food source also increases. Ant colony optimization has advantage to digital image processing and avoiding the convergence to optimal solution. ACO is pre arranged into three major purposes as given [4]:

Ant Solutions Construct –achieves the solution construction process.Pheromone Update–achieves pheromone trail updatesDaemon Actions–achieves extra updates from a global view point [4].Ant colony optimization is used to reduce the PAPR. In PTS based ACO method can be implemented by approximately changing the ant location. The modified Ant colony optimization is proposed to discover the optimal angle which helps to decrease the PAPR. The ant colony optimization has compensation of avoid the meeting to a nearby optimal solution [6].

F. Fire fly Algorithm (FF)

Fire fly algorithm is an alternative of swarm-based heuristic algorithm for constrained optimization [4], which is supported of the variation in light intensity. It facilitates the fire flies to travel towards brighter and further attractive position in arrange to achieve optimal solutions [2].The flashing light is associated with the objective function to be managed and formulate new optimization. We can idealize some of the essential flashing properties of suitable fireflies. The fire fly algorithm has the following idealized rules [4],[2].Every fire fly are unisex and they will travel towards further attractive and brighter.The quantity of attractiveness of firefly is comparative to its brightness, thus if there is not a brighter or more attractive firefly then it will travel randomly.The light intensity of a fire fly is finding out by the objective function.

The firefly algorithm has many advantages which make it very efficient for solving the optimization problems [4]. The proposed FF-PTS system supplies approximately the equal PAPR information as that of the optimal exhaustive PTS, while preserve a low computational load [2].

G. Bacterial Foraging Optimization (BFO)

BFO algorithm is an evolutionary computation algorithm based on the phenomenon of a bacterial colony. BFO algorithm consist of three most important mechanism namely, chemo-taxis, reproduction and elimination-dispersal [4].Chemo-taxis are the primary step for a bacterium, which create a cell to cell communication system. The main goal of bacterium is to optimize the best food position in pre-defined iteration. In reproduction, bacteria are set in downward order and divide into two; only the best healthiest bacteria tend to survive and placed in the same food location. In elimination-dispersal, only some bacteria are uninvolved and a few of the bacteria are located in random situation in the environment. BFO based PTS algorithm is a improved arrangement of phase factors for searching OFDM signals. The BFO-PTS algorithm can superior for PAPR reduction, for the reason that the BFO-PTS algorithm has just three control factors which can be effortless used[11].

IV. CONCLUSION

OFDM is a type of multicarrier modulation techniques, which offer high spectral efficiency, low realization complexity and less vulnerability to echoes. OFDM is infinitely used in different communication method. A most important weakness with OFDM is the Peak to Average Power Ratio (PAPR) which distorts the OFDM signal. To recover the PAPR reduction in OFDM systems, different Partial Transmit Sequence supported algorithms are created

International Journal of Communication and Networking System
Volume: 05, Issue: 01, June 2016, Pages: 52-55
ISSN: 2278-2427

in this paper. PTS is a non distortion technique which has need of little quantity of redundancy for the recovery of PAPR. But in the PTS technique, the computational complexity raises exponentially with increase in sub-blocks. Partial Transmit Sequence and its based algorithms are analysis in this paper to reduce the complexity of phase factor.

References

[1] Abhishek Arun Dash, "OFDM System PAPR Reduction Techniques in OFDM Systems," Bachelor Thesis, Department of Electronics and Communication Engineering National Institute of Technology, Rourkela2006– 2010.

[2] Aman Dhillon, Sonia Goyal, "PAPR Reduction in Multicarrier Modulations Using Firefly Algorithm," International Journal of Innovative Research in Computer and Communication Engineering, vol. 1, Issue5, July2013.

[3] Aman Dhillon, Sonia Goyal, "An Overview of PAPR Reduction Techniques in OFDM system," International Journal of Innovative Research in Computer and Communication Engineering, vol. 1,Issue5, May2013.

[4] BinithaS, SSiva Sathya, "A Survey of Bio inspired Optimization Algorithm," International Journal of Soft Computing and Engineering, vol. 2,Issue2,May2012.

[5] Chien-ErhWeng,Chuan-Wang Chang,Chuang-HslenChen,Ho-Lung Hung, "Novel Low-Complexity Partial Transmit Sequences Scheme for PAPR Reduction in OFDM Systems Using Adaptive Differential Evolution Algorithm," Springer Science+BusinessMedia,LLC,2012.

[6] Devinder Kumar, Preeti Singh, Jaget Singh, "Complexity Reduction in PTS based OFDM System: A survey," International Journal of Computing Applications, vol.69, No. 13, May2013.

[7] Er. Sahibinder Singh, Er. Devesh Mahor, "Hybrid Evolutionary Algorithm Based on PSO to Reduce Nonlinear effect for 802.11a High Speed Network," International Journal of Scientific& Engineering Research Volume 3, Issue4, April-2012.

[8] Marco Lixia, Maurizio Murroni, VladPopescu, "PAPR Reduction in Multicarrier Modulations using Genetic Algorithm," International Conference on Optimization of Electrical and Electronic Equipment, OPTIM2010.

[9] Neemi Taspinar, Dervis Karaboga, Mahmut Yildirim, Bahriye Akay, "PAPR Reduction using Artificial Bee Colony Algorithm in OFDM Systems," Turk J Elec. Eng.& Comp Sci., vol.19,No.1, 2011.

[10] R.Gayathri, V.Sangeetha, SPrabha, D.Meenakshi, N.R.Raajan, "PAPR Reduction in OFDM Using Partial Transmit Sequence (PTS)," International Journal of Engineering and Technology, vol.5, No.2 Apr-May2013.

[11] R.Manjith, M.Suganthi, "A Sub-optimal PTS Algorithm Based on Bacterial Foraging Optimization Technique for PAPR Reduction in MIMO-OFDM System," Journal of Theoretical and Applied Information Technology, vol. 57, No. 2, 20th Nov. 2013.

[12] Radheshyam Patel, ChiragPrajapati, Vishal Naik, Prof. T.P.Dave, "PAPR Reduction Technique in OFDM System," International Journal of Computer Science Trends and Technology, vol. 2, Issue 1, Jan-Feb 2014.

[13] VikasPreetTiwana, Sonia Singla, "Study of Various PTS Based Algorithms for PAPR Reduction in OFDM Systems," American International Journal of Research in Science, Technology, Engineering & Mathematics, March-May, 2013.

[14] 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.