PAPR reduction on MC-CDMA: a survey

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Abstract: **Multi Carrier Code Division Multiple Access (MC-CDMA) is a promising technology for 4G wireless communication systems. Orthogonal Frequency Division Multiplexing (OFDM) and Multi Carrier Code Division Multiple Access (MC-CDMA), which convert frequency selective channel to several flat fading channels thereby eliminating ISI and in turn need of equalization. Like all other multicarrier techniques MC-CDMA also suffers from high Peak-to-Average Power (PAPR) problem. To combat the problem of high PAPR, many techniques have been proposed. In this paper we have surveyed those techniques and analyzed that PAPR reduction is the non linear programming problem which is solved by optimization algorithms. Later we found that firefly algorithm is best suited algorithm based on previous study.**

Keyword: MC-CDMA

I. INTRODCUTION

In all multicarrier techniques Inverse Fast Fourier Transform (IFFT) is the main building block for generation of orthogonal subcarriers. Occasionally, all the subcarriers may get added to give a very high transmitted power. This high transmitted power may be significant in deviation from the mean power giving rise to high Peak-to-Average Power Ratio (PAPR) which is given as the ratio of maximum power to average power. This high PAPR may affect the orthogonality of the subcarriers. Once the orthogonality is lost many problems arise. High PAPR has been a bottleneck for multicarrier techniques.

Like all multi-carrier techniques, STBC MC-CDMA suffers from high PAPR. The high PAPR of the transmitted signal which in turn results in high input-back-off (IBO) for the power amplifier, drives the power amplifier to operate in non-linear region generating inter modulation (IM) products. IM causes out-of-band emissions and in-band distortions. Out-of-band emissions, or spectral regrowth, result an increased transmission bandwidth and causes Adjacent Channel Interference (ACI) and in-band distortion causes self-interference and degrades bit error rates performance at the receiver. So it is highly essential to alleviate this problem. To combat the problem of high PAPR, many techniques [5] have been proposed. The mathematical calculation of PAPR is as:

Let X denote data vectors such that [

] where , being no of subcarriers. The time domain complex baseband representation of this data block for a multicarrier signal can be represented as

Since the multicarrier signal is a combination of large no of independent subcarriers it may exhibit high PAPR. The PAPR of the transmitted signal can be represented by

From the central limit theorem, the in-phase and quadrature phase components of the time domain samples resemble Gaussian distribution with mean zero and variance of for sufficiently large no of subcarriers [6]. The numerator in the above equation represents the maximum power where the denominator is the average power which can also be termedas variance of the time domain samples.

In literature review it has been notified that comparison of algorithms is done graphically between PAPR and CCDF (Complementary Cumulative Distribution Function). The Cumulative Distribution Function (CDF) of amplitude of a signal sample can be represented as

where z is pre-set threshold. Then the CCDF can be defined as

CCDF=1- CDF

Thus CCDF of the PAPR denotes the probability that the PAPR of a data block exceeds a given threshold. Mathematically,

In the further section of paper, the previous work done is briefly classified in survey papers and research papers which all are dealing the PAPR reduction in OFDM or MC-CDMA. A total of 30 papers were studied out of which 8-10 papers were survey paper which give us an insight view of all previously used schemes. Last section is the conclusion section in which we concluded our analysis about the literature available.

II. PREVIOUS WORK

The complexity of PTS method increases exponentially with the number of sub blocks and Parandoosh, A. [2] saw this problem as non linear problem and suggested particle swarm optimisation (PSO) algorithm as the solution to achieve the optimum value of number of sub blocks. In [2] the computational complexity of conventional PSO algorithm is also reduced with improved PSO. Results are analysed for QPSK modulations and different sub blocks length. Improved PSO promised improvement than conventional PSO. Hung, H. [5] presented the mathematical formulation of MC-CDMA along with PTS scheme. It has also converted the problem to non linear complex problem and solved iteratively. Electromagnetism-Like method was adopted by the author and comparison with conventional PTS scheme in term of PAPR vs CCDF was shown. Results have been compared with other iteration methods like PSO, GA with different number of sub blocks and proposed method was the winner. Since the computational complexity reduction ratio increases as the number of sub-carriers increases, the proposed scheme becomes more suitable for the high data rate multi-carrier transmission systems. Kaur,J. [6] presented a paper reviewing different techniques to reduce PAPR. Author has compared simulation results for different schemes like selective linear mapping (SLM), partial transmit sequence (PTS) and hybrid algorithms. Hybrid technique is combination of Partial Transmit Sequence and Selective Mapping Technique. Using 8,16 and 32 users with Hadamard spreading algorithm, hybrid scheme proved to be minimising the PAPR most. As per the statistics published in the paper PTS reduces the PAPR to 2.9 dB, SLM to 2.2 dB and hybrid reduces to 1.5 dB form the original PTS PAPR. The same author presented a survey paper comparing the performance of PTS and SLM schemes only [8] and another survey paper for all PAPR reduction scheme is also published [12]. Wen [7] in his paper used PSO algorithm to reduce the PAPR iteratively. Weighting factors of sub blocks in PTS scheme were tuned by PSO and it analyzed the PAPR reduction performance which is derived by using adjacent, interleaved, and randomsubblock partitioning methods. Random sub block partitioning method has derived the most effective performance, and interleaved sub block partition method has derived the worst. As the number of sub blocks is increased, PAPR can be further reduced. Simulations results show that PSO-based PTS method is an effective method to compromise a better trade-off between PAPR reduction and computation complexity. Again Gupta, N. [9] used the concept of nonlinear equations to minimise the PAPR and bio inspired bacterial foraging optimisation (BFO) which is based on the motion of E. Koli bacteria in search of its food. Results are compared with many other heuristic algorithms like genetic algorithm (GA), simulated annealing (SA), PSO. EM etc and BFO seems to be performing well than rest. Kumar D. [10] again published a survey paper of PAPR reduction using PTS scheme and proposed Ant Colony optimisation can give better reduction. Singla K. [12] proceeded the work suggested in [10]. Teh author used the ant colony optimisation (ACO) algorithm to reduce PAPR. It calculated PAPR for different number of users usingBPSK and QPSK modulation. From MATLABsimulation it is concluded that BPSK modulation is best for PAPR reduction in MC CDMA. PAPR reduction increases as we increase number of user. Mariano in [16] proposed a PAPR reduction scheme for space-frequency block coding MC-CDMA downlink transmissions that does not require any processing at the receiver side because it is based on the addition of signals employing the spreading codes of inactive users. Further it analysed various schemes for PAPR reductions considering it as a second order programming problem. R. Manjith [18] in 2013 use again the Bacterial foraging optimisation scheme which was also used in paper [9]. Sajjad A. Memon [20] extended the previously proposed selective mapping method for PAPR control in MCCDMA to error-control selective mapping coding (EC-SLM) for both effective PAPR reduction and error control. Several well known EC codes such as convolution codes, turbo codes and LDPC codes can be adopted in new EC-SLM approach. Simulation results have shown that, the EC-SLM is more effective than the SLM in reducing the PAPR of MC-CDMA and avoid the need for the transmission of explicit side information. Simulation results also showed that the increasing number of PAPR control bits results in much reduced PAPR value but also increases the system complexity. R. Manjith [20] used three non linear companding algorithms because of their least complexity. These non linear companding algorithms transform the Gaussian distributed OFDM signals to uniformly distributed signals. D. Narendra [21] extended the concept of PAPR reduction to 4G wireless technology. He compared various reduction schemes like Clipping, Companding, Selective Mapping (SLM), Interleaving, Tone reservation (TR) Tone Injection (TI) and Partial Transmit Sequence (PTS) and finally simulated PTS based scheme in MATLAB. Tanairat [22] did the work different form previously studied. He used re ordering of clusters in frequency domain to reduce PAPR rather than any PTS based scheme. He proposed the new PAPR reduction method based on the packet-switched transmission systems in which all the clusters within the certain number of OFDM symbols have the sequential cluster ID numbers embedded in the header of each cluster. The salient features of the proposed method are to improve the PAPR performance both for the data information and cluster ID numbers simultaneously by re-ordering of clusters in the frequency domain at the transmitter and to reconstructthe original order of clusters by using the cluster IDnumbers embedded in the data information at the receiver. This paper also proposes the computation complexity reduction technique for the ROC method by using the feature of IFFT processing. The proposed ROC method is completely different from the PTS method which is required to inform the phase coefficients obtained after the PTS processing as the side information to the receiver separately. From this fact, The PTS method has a difficulty to embed the phase coefficients of PTSinto the data information separately without the degradation of PAPR performance.

After reviewing so many papers we found that PAPR reduction problem is a non linear programming problem which is minimised iteratively. Maximum iteration methods used are either PSO or variant of PSO. Because of this we have studied some paper on PSO too. We have come across many advantages of PSO algorithm like it is a kind of versatile algorithm which can be fitted to any scientific and research problem [14]. Compared to other optimisation algorithms it has a large searching space. Even due to many advantages and good optimisation capability of PSO, it has a drawback that it falls into local minima easily. That's why for more complex problems it may skip the optima point sometimes. To remove it we searched a more efficient algorithm which is designed on PSO platform but not the variant of PSO. Firefly algorithm is the algorithm which came to remove the drawbacks of PSO with PSO's advantages. Firefly algorithm has two major advantages: automatical subdivisionand the ability of dealing with multimodality [26].

III. CONCLUSION

We have studied many papers related to PAPR reduction, published in between 2010-14. After studying 27 papers for insight view of what till now has been done for PAPR reduction in wireless communication, it has been noticed that every author has termed as PAPR reduction scheme as non linear problem and used optimisation schemes to reduce that. Many optimisation algorithms have been used by different authors and these are categorised as in table 1 in appendix. Most of the algorithms are based on PSO optimisation or it's variant but due to drawback falling in local optima, we have found firefly algorithm most efficient than PSO.

Table 1 PAPR reduction techniques comparison

Technique name	Power increase	Distortion-less	Loss in data rate	Computational Complexity
Amplitude clipping & filtering	No	No	No	Low
Coding	No	Yes	Yes	Medium
Partial Transmit Sequence	No	Yes	Yes	Very High
Selected Mapping	No	Yes	Yes	High
Interleaving	No	Yes	Yes	Medium
Tone Reservation	Yes	Yes	Yes	Medium
Tone Injection	Yes	Yes	No	Medium
Active constellation extension	Yes	Yes	No	Medium

IV. REFERENCES

[1]. B. Sarala and D.S. Venkateswarulu B.N.Bhandari,"Overview Of MC CDMA PAPR Reduction Techniques" International Journal Of Distributed And Parallel Systems (IJDPS) Vol.3, No.2, March 2012

[2]. Sarala, B., D. S. Venkateswarulu, and B. N. Bhandari. "Overview Of MC CDMA PAPR Reduction Techniques." International Journal of Distributed & Parallel Systems 3.2 (2012).

[3]. Ali AsgharParandoosh, JavadTaghipour and VahidTabatabaVakili, "A Novel Particle Swarm Optimization For PAPR Reduction Of OFDM Systems" International Conference on Control Engineering and Communication Technology, IEEE, 2012

[4]. Branislav M. Popovi´c," Spreading Sequences for Multicarrier CDMA Systems" IEEE Transactions On Communications, Vol. 47, No. 6, June 1999

[5]. Ho-Lung Hung and Yung-Fa Huang, "Peak To Average Power Ratio Reduction Of Multicarrier Transmission Systems Using Electromagnetism-Like Method" International Journal of InnovativeComputing,Volume7, Number 5(A), May 2011

[6]. JaswinderKaur, KomalArora,"Performance analysis of PAPR reduction techninques for MC-CDMA system" International Journal of Scientific & Engineering Research, Volume 4, Issue 8, August-2013

[7]. Jyh-HorngWen, Shu-Hong Lee, Yung-Fa Huang, and Ho-Lung Hung," Suboptimal PTS Algorithm Based on Particle Swarm Optimization Technique for PAPR Reduction in OFDM Systems" EURASIP Journal onWireless Communications and Networking Volume 2008.

[8]. Gagandeep Kaur1, RajbirKaur, "Comparative study of SLM and PTS techniques for PAPR Reduction of an MC-CDMA system" IJERA, Vol. 2, Issue 4, July-August 2012

[9]. Neha Gupta, GarimaSaini,"Performance Analysis of BFO for PAPR Reduction in OFDM" International Journal of Soft Computing and Engineering (IJSCE) , Volume-2, Issue-5, November 2012

[10]. Devinder Kumar, Preeti Singh, Jaget Singh,"Complexity Reduction in PTS based OFDM System: A Survey" International Journal of Computer Applications Volume 69– No.13, May 2013

[11]. KanchanSingla, RajbirKaur," Ant Colony Optimization Algorithm For PAPR Reduction In Multicarrier Code Division Multiple Access System" IJERA,Vol. 4, Issue 6(Version 5), June 2014

[12]. PavaniSumala, R.Prasanth ,R.A.S.Bharadwaj , ShaikAzeez,"Performance Analysis Of Multicarrier Cdma Systems" IJIRCCE, Vol. 2, Issue 1, January 2014.

[13]. Qinghai Bai,"Analysis of Particle Swarm Optimization Algorithm" Compuet& Information Science, Vol 3, No. 1, 2010.

[14]. GagandeepKaur, RajbirKaur, "PAPR Reduction of an MC-CDMA System through PTS Technique using Suboptimal Combination Algorithm" IJERA Vol. 2, Issue4, July-August 2012.

[15]. Mariano García-Otero, Luis Alberto Paredes-Hernández, "PAPR reduction in SFBC MIMO MC-

CDMA systems via user reservation" EURASIP Journal on Advances in Signal Processing, 2011.

[16]. Neha Gupta, GarimaSaini," Performance Analysis of BFO for PAPR Reduction in OFDM" IJSCE, Volume-2, Issue-5, November 2012

[17]. R.Manjith, M.Suganthi," A Sub-Optimal Pts Algorithm Based On Bacterial Foraging Optimization Technique For Papr Reduction In Mimo-Ofdm System" JATIT, Vol. 57 No.2, 2013

[18]. Zbynˇek FEDRA, Roman MARˇSA´LEK, Vladim´ır SˇEBESTA,"Chip Interleaving and its Optimization for PAPR Reduction in MC-CDMA" RADIOENGINEERING, VOL. 16, NO. 4, DECEMBER 2007

[19]. Sajjad A. Memon, A. W. Umrani, F. A. Umrani, and A. K. Baloch," A Peak to Average Power Ratio Reduction of Multicarrier CDMA System Using Error Control Selective Mapping" Progress In Electromagnetics Research Symposium Proceedings, Marrakesh, Morocco, Mar., 2011

[20]. R.Manjith, Dr.(Mrs).M.Suganthi, "PAPR Reduction in OFDM & MC-CDMA System using Nonlinear Companding Techniques" ACEEE International Journal on Network Security, Vol 1, No. 1, Jan 2010

[21]. D.Narendra, Dr.P.Sudhakara Reddy,"PAPR Reduction Technique in OFDM System For 4G WirelessApplications Using Partial Transmit Sequence Method", Journal ofElectronics and Communication Engineering ResearchVolume1 ~ Issue1 (2013)

[22]. Tanairat Mata1, Katsuhiro Naito1, Pisit Boonsrimuang, Kazuo Mori1, Hideo Kobayashi, "Proposal of PAPR Reduction Method for OFDM Signalby Re-Ordering of Clusters in Frequency Domain", *nt. J. Communications, Network and System Sciences*, 2013, 6, 388-394

[23]. Leman Dewangan, Mangal Singh, Neelam Dewangan, "A Survey of PAPR Reduction Techniques inLTE-OFDM System", International Journal of Recent Technology and Engineering (IJRTE), Volume-1, Issue-5, November 2012.

[24]. Monika Phulia1 and O.P. Sahu, "Peak-to-Average Power Ratio (PAPR) Reduction of OFDM Signals Using a Modified PTS Technique", International Journal of Electronic and Electrical Engineering, Volume 7, Number 1 (2014), pp. 79-84.

[25]. P.Mukunthan, and P.Dananjayan,"Modified PTS Combined with InterleavingTechnique for PAPR Reduction in MIMOOFDM system with Different Subblocks andSubcarriers", IAENG International Journal of Computer Science, 39, 21 November 2012

[26]. Xin-She Yan,"Firefly Algorithm: Recent Advances and Applications", arXiv:1308.3898, 18 Aug 2013

[27]. Saibal K. Pal, "Comparative Study of Firefly Algorithm and Particle Swarm Optimization for Noisy NonLinear Optimization Problems", I.J. Intelligent Systems and Applications, 2012, 10, 50-57