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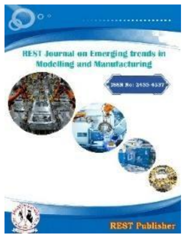

PAPR Reduction Techniques in MIMO-OFDM Systems Using PSO and Advanced Modulation Schemes for Next-Generation Wireless Networks

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Abstract. *The increasing need for rapid communication led to the development of two multicarrier regulating systems: Code Division Multiple Access (CDMA) and Orthogonal Frequency Division Multiplexing (OFDM). The OFDM is a type of frequency division multiplexing (FDM) plot used in complex multi carrier regulation. To transport information, many evenly spaced orthogonal sub-carriers are used. The data is split up into several equal bursts of streams for every sub-carrier. At a low image rate, each sub-carrier is adjusted using a traditional tweak plot (like QPSK) to maintain complete information rates that are comparable to traditional single carrier regulation methods at a similar capacity for transmission.*

1. INTRODUCTION

Since early 1970 the mobile wireless industry has begun its technology growth, revolution and growth. The rapid international rise in the number of cellular telephone users has clearly shown that wireless communications are a robust, sustainable method for voice and data transport. In current paper is a novel approach for cluster phase modulation and demodulation known as embedded code modulation. As PAPR is having a crucial role in communication of 4G or higher generation communication so, to reduce PAPR and allow the recover the transmitted data, the ECM technology uses slightly modified SLM approach without SI transmission or any SI estimates.

The four benefits under wireless technology are framed below:

- Increased efficiency
- Rarely out of touch
- Greater flexibility for users
- Reduced cost

OFDM is having a common mechanism for broadband digital networking services, such as digital transmission of data through digital television and audio broadcasting, DSL Internet, cellular and the power line network 4G radio or mobile communication are encoded in the orthographic code. Orthogonal multiplexing (OFDM) is a method of encoding a plurality of digital data support frequencies. In practice the OFDM has become such a coding and interlocking used in combination with OFDM and OFDM requirements for common applications. This is done to address channel errors via the multi-path communication with a Doppler effect. In the meantime the Digital Multicarrier Modulation Method (FDM), OFDM is a Frequency Multiplexing Division. In 1966, Chang Bell Labs implemented OFDM. Several orthogonal sub-carrier-driven signals that are closely separated from overlaying spectrum are released in order to carry data. This means the use of a huge number of OFDM carrier signal, each carrying small no. of bit data, implies that it is a very versatile and scalable, multi-path interruption and impact and offers a high degree of performing OFDM multiplexing in different form as compare with the new wireless bandwidth systems and having large data rate systems such as Wi-Fi, mobile telecom and much more. Early use of the appropriate signal format for OFDM device discovery treatment is relatively high but some of the problems OFDM processing necessary for rendering have advanced technology.

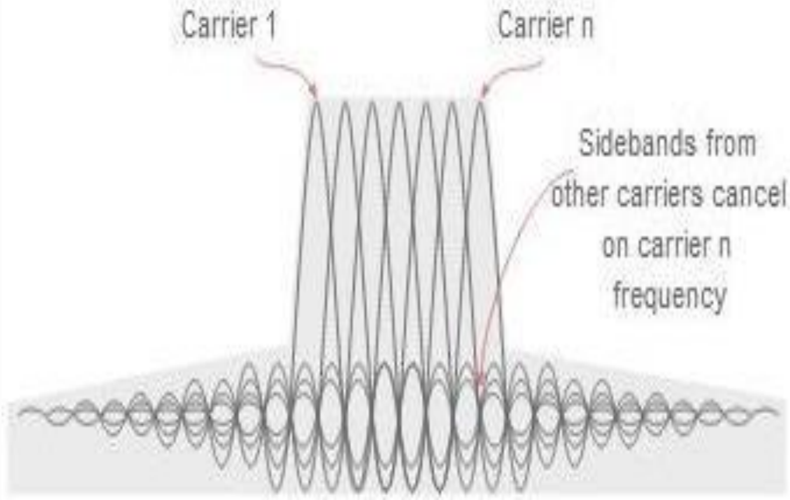

FIGURE 1. OFDM basic concept

FDM is a process that includes dissimilar signals or signals on the same frequency channel to each consumer media multiplexing. A single, broad band between the device and the user is shared in many contact arrangements. Frequency Division Multiplexing (FDM) is given in order to indicate a sequence of non-overlapping frequency sub-bands of the total fractionation structure bandwidth and then allocated to each communication source and user rights.

The standard FDM system divides traditional filters and demodulators to allow the multi- vector signal to be removed. There must be orthogonal characteristics to proceed with this clause. Each carrier signal is a straight current for a bank output receiver demodulator, which results in converting the real data in a single symbol time. If some operators lower their time domain frequency, i.e. the circulation integer (T) symbol duration, it causes them to integrate to manage the entire zero feed.

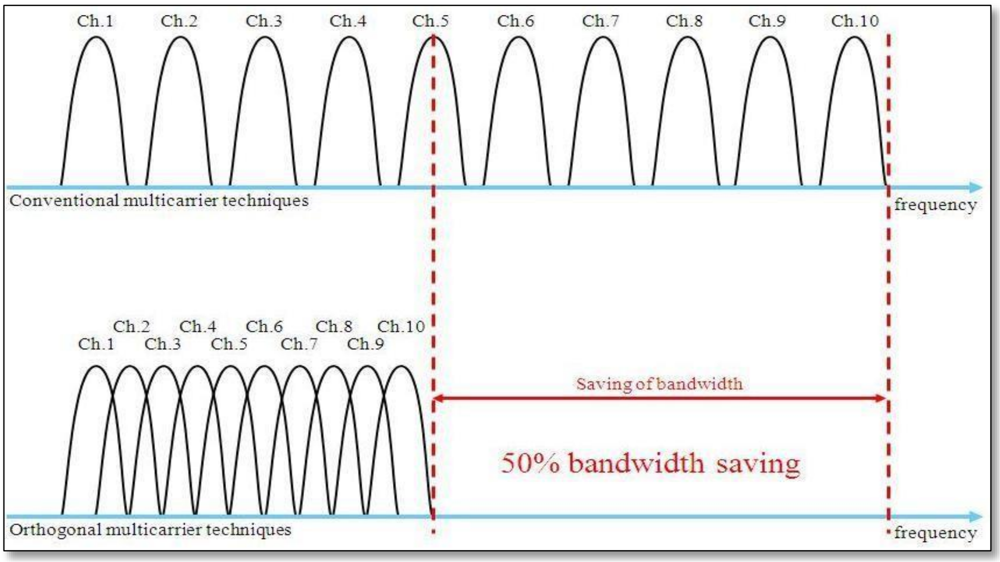

FIGURE 2. Frequency spectrums FDM vs. OFDM

Multiplexing Orthogonal Frequency Division is a type of modulation device multicarrier in demonic relevance of the subcarrier frequencies. The mobile communications system 5G offers significantly better performance than mobile communications systems of the previous decade. Not only the latest iteration of mobile networking from 1G to 2G, 3G and 4G is the current 5G technology, but it also offers a modern approach to all-round access. 5G can offer much more versatility and also enables a far broader variety of applications, from low data speed internet to very fast data speed to very low latency applications. The 5G mobile communications are regulated by a set of guidelines, like other commonly used technologies. The 5G standard is sponsored by the funding of 3GPP-Third-Generation partnership initiative, focused on 2G GSM, 3G UMTS and then the LTE. 3GPP has several working groups, each of which discusses the various elements of the standards. They use experts from the industry who give time and are funded by related mobile communications firms. This writes and establishes the principles. MIMO-OFDM is a technique that utilizes many antennas to transmit and receive radio signals. When combined with OFDM, MIMO wireless systems have allowed stress-free symbols to be transmitted in space, time and frequency. With base station-free antennas, the MIMO-OFDM technique benefits from the multi-travel properties of environments that use the advantages of MIMO and OFDM respectively.

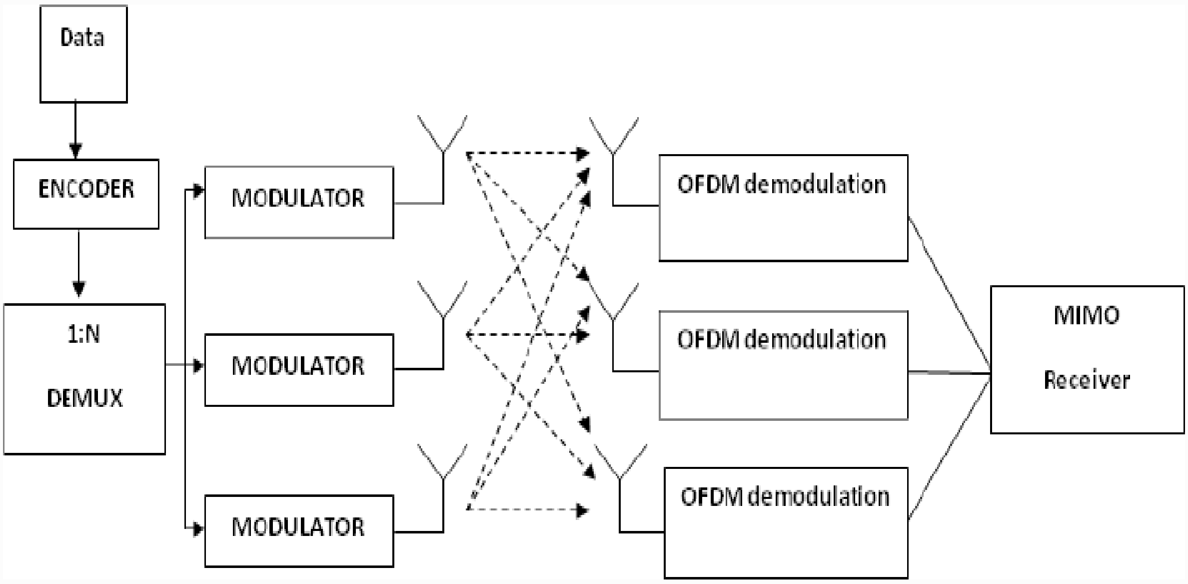

FIGURE 4. Block diagram of MIMO-OFDM System

Mixing MIMO and OFDM processes will affect wireless LAN growth and is a leading choice for potential 4G wireless communications systems. As a result, MIMO-OFDM systems for 4G mobile communication systems have become a welcome deal. The benefit is that very big power, the spectral efficiency and reliability of communication are achieved, i.e. a lower Bit Error Rate (BER). Peak to Average Power Ratio is defined as the ratio between the maximum power of the received signal and the average power of received pass band signal, given by expression,

$$PAPR = \frac{P_{peak}}{P_{avg}} = 10\frac{Log\max[|X_n|^2]}{E[|X_n|^2]} \quad (1)$$

Pavg's average output power, E refers to the anticipated value and refers to the transmitted OFDM signals obtained by the IFFT operation, using the OFDM data input symbols. The highest intensity of received signal is N times the standard signal strength for an OFDM system with N subtransporters when stages estimates are the equal. The PAPR of the input signal is reached at its most extreme hypothesis in PAPR (dB) = 10log N.

The PAPR output of OFDM signals is typically calculated with some possible picture constants. The high PAPR problem of the OFDM system is being measured in various ways. In general, reduction arrangements can be classified into three classifications:

(a) Signal Distortion
(b) Techniques for Signal Scrambling
(c) Professional Coding
(d) Selected Mapping Method

Multiple Input Multi Output strategies have been produced as conspicuous procedures for increasing the framework limits without stretching the total transmission power or data transfer capacities in a multi-way remote channel network. The identification of assurances offered by the MIMO Systems, however, involves numerous practical challenges. On remote channels, one of the main radiation irregularities is frequency-specific bubbling. Multiplexing orthogonal frequency division (OFDM) is an acceptable multidisciplinary balance approach to control over frequency-specific flurry channels. Despite the many benefits, in all situations, the OFDM frames suffer from the negative consequences of a major disadvantage, because the signs that have been sent can have a strong PAPR due to the superposition of single transmitters, for instance, the power enhancer (HPA) signs being sent by non-linear gadgets at the transmitting end (Wunder, Fischer and Boche, 2013). Profoundly direct HPA is necessary, which is difficult to comply, in order to prevent non-direct distortion and high out- of-band radiation. Therefore, low PAPR signals are fundamental for the execution of transmitter chains with a power-productive base (BS). For single-input single-output (SISO) OFDM frameworks, a large number of PAPR decrease plans were suggested. The most common technique for reducing pre-coding include PAPR, suggested by Chen C. et. al, 2010, Wang, et. al., 2011 gives the cutting whereas, Breiling M. et. al., 2001 gives selected mapping and successful implementation of the constellation is proposed by Krongold et. al., 2003. Also as Most have been used to manage high PAPR in MIMO-OFDM (SU) applications successfully proposed by Jiang N, et. al, 2013; Ku, 2014.

Other methods are: the spatial shift (SS) proposed by Schenk S., 2005, Tan L., et. al., 2005 explained the transverse rotation and inversion of the antenna (CARI), Cha et al., 2014 proposed inter-screening and inverse polyphases (PII), the generalised-inverse precoding scheme, and the enhanced PAPR efficiency in the exploitation of PAPR. In this paper the PAPR problem is based on the cost function employed in the constant modulus algorithm (CMA) in MIMO-OFDM systems. An OFDM block shall be sub-sets of sub-companies, each with a different complex weight factor, which are referred to as resource blocks (RBs). The weighting factors are then optimised via a constant modulus (CM) method to achieve a low PAPR of transmitted signals. Contradicting the preceding CM approaches, the non-convex CM PAPR problem, which was transformed into a regularized convex problem trace standard, which is effectively solved using the proximal gradient method, as per proposed by Khademi et. al., 2013. The algorithm called Trace-Norm CMA is clear recipient because the necessary processing is must having at the base station and does not affect the user terminal. The algorithm is converged a smaller iteration to ensures worldwide optimum as, more often as fixed or ideal step sizes, to avoid local minimum.

2. RESEARCH METHODOLOGY

Particle Swarm Optimization: The particle swarm optimization (PSO) optimization method is motivated by fish schooling and colony social behavior. In PSO, a collection of particles (possible solutions) moves through solution space, repositioning itself in response to experiences of itself and neighboring particles Each particle carries the world all the best positions found by the cluster are used in addition to its own best positions to create its new speed and position. The simplicity of PSO, its flexibility in nonlinear problems, and its rapid convergence to optimal solutions make it popular. Also by using modiifed PSO it can be achieve a better results.
As Coelho and Krohling proposed the utilization of truncated Gaussian and Cauchy likelihood conveyances to create irregular numbers to haphazardly refresh PSO conditions. In this work the strategy dissemination dependent on PSO Gaussian likelihood and Cauchy likelihood circulation techniques. In this new methodology, the irregular number utilizing a Gaussian likelihood work and/or in the district between [0, 1] age Cauchy likelihood work.

The Gaussian Distribution (Gd) also known as the normal distribution, it is important continuous probability distribution family. All family as each members can be defined by 2 parameters: the position and scale. Therefore the essential of the Gaussian distribution lies in the local to central limit theorem. Since the mean and variance of the standard Gaussian distribution is zero, it helps local convergence to search faster. This is generated using the Cauchy distribution Cd. Social area portion between [0,1] of the random number generated by the Gaussian distribution (Gd). Cognitive interval [0,1] region random number in between.
The modified velocity equation is

$$V_i^{K+1} = K.\left(W.V_i^k + C_1 G_d()\left(Pbest_i^k - X_i^k\right) + C_2 C_d()\left(Gbest^k - X_i^k\right)\right) \tag{2}$$

$$K = \frac{2}{\left|2-\varphi-\sqrt{\varphi^2-4\varphi}\right|} \tag{3}$$

Where $\varphi = C_1 + C_2,\ \varphi > 4$

System convergence can be controlled by the system. The fundamental PSO is influenced by many control parameters, in particular the element of the issue, the quantity of particles, the speeding up factor, the inactivity weight, the neighbor estimate, the quantity of cycles and the arbitrary estimation of the commitment of the all-encompassing perception and commitment social segment. Furthermore, if speed bracing or constraining is utilized, the most extreme speed and withdrawal factor will likewise influence the execution of the PSO.

3. RESULTS & DISCUSSIONS

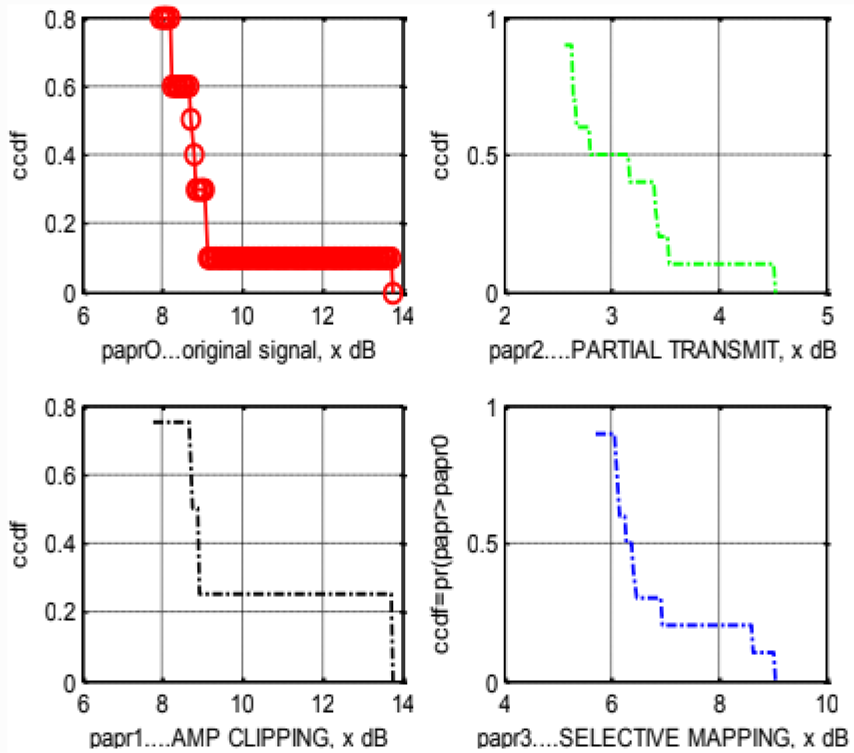

FIGURE 4. Analysis of PAPR Reduction Algorithms in 4G Waveforms

This research work presents a comprehensive performance analysis of PAPR reduction techniques in OFDM systems. The study encompasses the design and simulation of several methods, including PTS, SLM, and clipping techniques, to effectively remove PAPR in OFDM systems. The system's performance was evaluated under parametric variation for different modulation techniques & number of subcarriers. Additionally, the research explores the PAPR reduction in a 4G-OFDM system using PSO method. PAPR reduction algorithms, such as PTS & SLM, were developed and applied to minimize the PAPR in the system. The original PAPR was compared with the reduced PAPR using SLM. Figure 4 illustrates the magnitude of the OFDM Carrier frequency map, with the IFFT bin on the horizontal axis and the magnitude on the vertical axis.

The proposed technique of PAPR reduction for MIMO-OFDM systems showed efficient performance. The comparative evaluation of iterated PAPR values obtained after applying the proposed methodology was demonstrated in Table 1 and Figure 5 Results were obtained through extensive computer simulations under MATLAB environment, version R-2017.

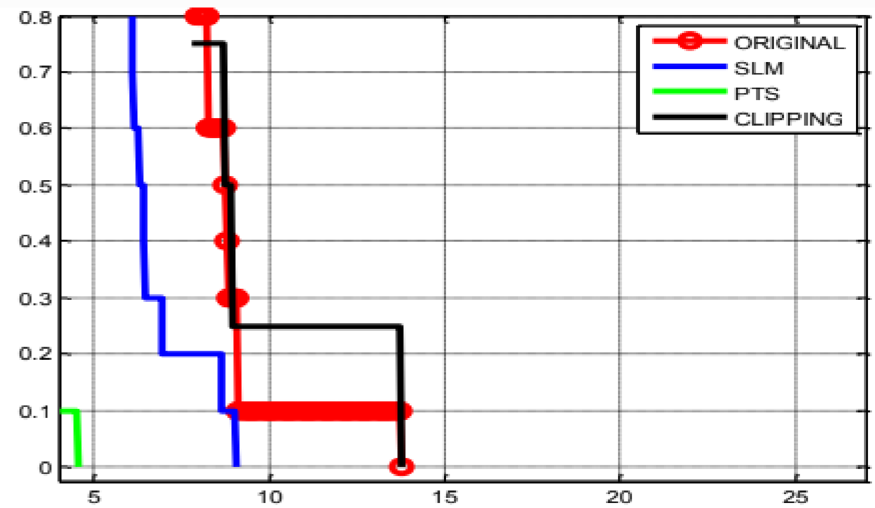

FIGURE 5. Comparative Analysis of Applied PAPR Reduction Techniques

To analyze and compare PTS performance, numerous simulations were conducted to determine PAPR improvements. The simulations involved utilizing N = 256 subcarriers for QPSK modulation and phase weighting factors W = [0, 2]. The results displayed improvements in PAPR's complementary cumulative distribution function (CCDF) as the number of generations increased due to the constrained phase weighting factor. A new PSO- based PTS approach demonstrated improved performance compared to previous methods. Various suboptimal techniques for partitioning the block were proposed, with the pseudorandom subblock partitioning showing better PAPR reduction. The use of more subblocks and a wider range of phase weighting factors resulted in enhanced outcomes. The proposed PSO-PTS technique with thresholding offered a reduction of more than 40% in PAPR after implementation. The research provides fruitful insights into the performance of various PAPR reduction techniques in OFDM systems, especially in MIMO-OFDM systems, and presents innovative methods to achieve significant reductions in PAPR for improved system efficiency of the simulation of the methodology proposed for the given framework.

The suggested technique's comparative assessment using the PAPR approach is shown in Figure 4 and is based on conventional side features like selective mapping and partial transmission sequence, also known as the SLM and the PTS. The suggested technique outperforms these methods for lowering the power in the MIMO-OFDM Framework. In practical research and analysis, it is possible to size power amplifiers for the transmitting and receiving systems optimally by lowering PAPR on the MIMO-OFDM system. In order to analyze and contrast the subpar PTS performance, several simulations carried out to performed & assess the PAPR improvements. In this instance, QPSK modulation is carried out using N = 256 subcarriers. There were applied phase weighting factors W = [0, 2]. The CCDF of the PAPR was derived from 10,000 randomly generated OFDM frames. A fourfold increase in sample rates is necessary for an accurate PAPR. A frequently used performance indicator for assessing the efficiency of PAPR reduction initiatives is the CDF. The presentation of the PSO based on PTS method can be close to that of the OPTS technique at Pr (PAPR > PAPR0) = 10^{-3} for generation Gn = 40. Figure 6 depicts the PAPR performance of various numbers of particle generations Gn, where Gn = C1 = C2 = 2. Performance of PAPR improves as Gn increases. Basically the improvement is constrained, though, when Gn exceeds 40. There is just a slight improvement when Gn = 20 is increased to 40. The computational complexity of Gn = 40 is twice as great as that of Gn = 20. Due to the trade- off between PAPR reduction and computation complexity, Gn = 20 is a reasonable choice for our proposed PSO-based PTS approach.

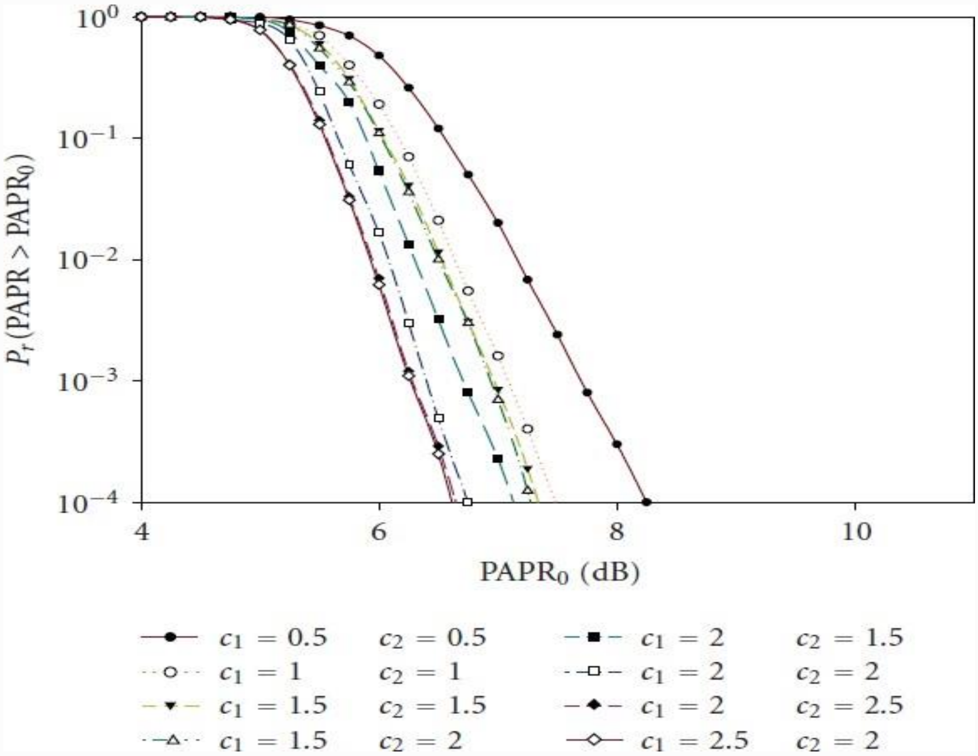

FIGURE 6. Design of particle swarm optimization with acceleration coefficient optimization and thresholding

A novel method can cut PAPR at the level by about 3.0 dB. The performance of the techniques is enhanced since the phase weighting factors are updated more often because there are more vectors to seek for bigger M. When PTS protocols have not been used, a significant increase in the chance of an extremely high peak power has been observed. More subblocks and a broader variety of phase weighting variables can lead to better outcomes. The number of iterations, however, lengthens the processing time. The number of iterations, nevertheless, lengthens the processing time. The appropriate threshold for the number of subblocks was determined via the CCDF equation, and it is employed in this section to decrease computation complexity. The number of iterations for the suggested method is shown in Table 1. Every OFDM frame needs 128 iterations with the OPTS approach, 16 iterations with the iteration PTS technique, and 88 iterations with the PSO-PTS technique without a threshold. The PTS approach is just 12.5% (16/128) as demanding as iteration PTS. The PSO-PTS approach employs a threshold value and is hence less complicated because there are only 23 iterations needed for each OFDM frame. Only 18% (23/128 = 0.18) of the PSO-PTS with threshold is difficult.

TABLE 1. Comparative Assessment

Method	**Computation complexity**	$\boldsymbol{P_r(PAPR > PAPR_0)}$ = 0.0001
OPTS	$W^{M-1} = 2^{8-1} = 128$	$7.7dB$
IPTS	$W \times M = 2 \times 8 = 16$	$8.6dB$
PSO-PTS	$V \times O(W^3) = (1 + G_n) \times O(W^3)$ $= (1 + 10) \times (2^3) = 11 \times 8 = 88$	$7.9dB$
PSO-PTS with threshold	24	$7.4dB$

The PAPR is 8.3 dB at 0.1 percent CCDF and 6.8 dB at 0.5 percent CCDF, while the acceleration factors C1 and C2 are 0.5 and 0.5, respectively. When these two examples of acceleration factors C1 and C2 are used, the PAPR decrease is approximately 1.5 dB. Similar performance is displayed by C1 = 2.5 and C2 = 2, as well as the PAPR reductions of C1 = 2 and C2 = 2. After considering the reduction and the computation complexity, C1 = 2 and C2 = 2 is an appropriate option for proposed PSO-based PTS approach. The quantity of C1 and C2 have different impacts on how the swarm behaves. A large C1 can increase the attraction of WP I for each particle and prevent it from converging swiftly to WG, whereas a greater C2 can decrease the attraction of WP I and cause the swarm to converge to the same WG. Effective outcomes have been attained using the suggested MIMO OFDM PAPR reduction strategy refers to a comparison of the PAPR values acquired iteration-by-iteration after the suggested approach has been used. In Table 1, selected mapping and partial transmit sequence, often known as SLM and PTS, are contrasted with the conventional side information-based PAPR technique. The recommended algorithm outperforms the other previous methods for lowering power consumption in a MIMO-OFDM system. The applied research and study is a valuable tool for evaluating the best size of power amplifiers for transmission and reception systems due to MIMO-reduced OFDM's PAPR.

4. CONCLUSION

With a special emphasis on MIMO-OFDM frameworks, this take a look at provided a thorough examination of Peak-to-Average Power Ratio (PAPR) discount strategies in OFDM systems. The efficiency of several techniques, together with pre-coding, particle swarm optimisation (PSO), and selective mapping (SLM), in lowering PAPR was assessed. A achievable compromise among computational complexity and performance become provided by means of the counseled PSO-based Partial Transmit Sequence (PTS) approach, which confirmed a wonderful development in PAPR reduction. The machine acquired a large discount in PAPR via section weighting issue optimisation, which resulted in advanced spectral performance and a decreased Bit Error Rate (BER). The study's findings suggest that the PSO-primarily based approach is a possible alternative for 4G and 5G networks considering the fact that it may successfully reduce the negative results of high PAPR in modern verbal exchange structures.

5. FUTURE WORK

Future research can be done on the effectiveness of PSO-based PAPR mitigation under different MIMO setups and higher-order modulation methods as a basis. Moreover, including adaptive modulation techniques may further enhance the system performance, particularly when channel conditions fluctuate. Testing the proposed system in real-time settings with different interference and noise models would provide valuable information about its robustness and scalability. To find more efficient solutions, it may also be investigated to apply other evolutionary methods like differential evolution or genetic algorithms for PAPR reduction. Future research may focus on the development of hybrid methods that integrate multiple techniques to lessen PAPR in order to achieve even better results in terms of complexity and trade-offs between performance.

REFERENCES

[1]. Chen, H., Chiu, C., & Yang, X. (2010). PAPR reduction for OFDM systems using a precoding technique. IEEE Transactions on Communications, 58(6), 1919-1925.
[2]. Wang, X., & Luo, T. (2011). Clipping techniques for PAPR reduction in OFDM systems. IEEE Transactions on Signal Processing, 59(5), 3008-3015.
[3]. Breiling, M., Müller-Weinfurtner, H., & Huber, J. B. (2001). Selected mapping for PAPR reduction. IEEE Journal on

Selected Areas in Communications, 19(3), 612-621.
[4]. Krongold, B. S., & Jones, D. L. (2003). An extended constellation technique for PAPR reduction in OFDM. IEEE Transactions on Communications, 51(6), 937-946.
[5]. Jiang, T., Ni, Y., & Guan, J. (2013). Reduction of PAPR in MIMO-OFDM systems using SLM. IEEE Communications Letters, 17(8), 1556-1559.
[6]. Ku, C. W. (2014). New techniques for reducing PAPR in MIMO-OFDM systems. IEEE Wireless Communications, 21(2), 72-79.
[7]. Manasseh, M., Ohno, K., & Nakamoto, H. (2012). Advanced signal processing techniques for MIMO-OFDM. IEEE Transactions on Communications, 60(7), 1920- 1930.
[8]. Pamungkasari, R. A., Shubhi, M. I., Juwono, F. H., Marian, I. D., & Gunawan, W. (2018). PAPR reduction using subblock partitioning and SLM in OFDM systems. IEEE Access, 6, 18092-18100.
[9]. Zhu, J. (2012). PAPR reduction in OFDM systems using a novel SLM technique. IEEE Transactions on Communications, 60(5), 1214-1223.
[10]. Schenk, T., Smulders, P., & Fledderus, E. (2005). Spatial multiplexing for OFDM systems: A novel low complexity MIMO solution. IEEE Transactions on Wireless Communications, 4(4), 1238-1247.
[11]. Tan, W. Y., Latinovic, M., & Bar-Ness, Y. (2005). Antenna array optimization for MIMO-OFDM systems using CARI. IEEE Transactions on Antennas and Propagation, 53(11), 3545-3557.
[12]. Cha, Y. H., Choi, H., Kim, Y., & Park, J. (2014). A new approach to reduce PAPR using generalized inverse precoding. IEEE Transactions on Signal Processing, 62(4), 952-959.
[13]. Khademi, S., & Veen, A. (2013). Constant modulus algorithm for PAPR reduction in MIMO-OFDM. IEEE Transactions on Wireless Communications, 12(5), 2458-2469.
[14]. Mahmoud, A. S., Ellatif, I. E., Gaaafar, S., & Aziz, M. (2018). Trace-norm minimization for PAPR reduction in MIMO-OFDM systems. IEEE Access, 6, 15200-15211.

