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Optimization Based PAPR Reduction Approach with PTS-TR Block Modeling

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ABSTRACT

OFDM is orthogonal frequency division multiplexing technique is studied by the researchers. This technique has an issue of PAPR(Peak-to-Average Power Ratio) which must have low value for better communication. Various mechanisms have been proposed to reduce PAPR. However, there are very complex and has low accuracy. In this paper, the existing approaches for reducing PAPR value are studied and a novel PAPR reduction technique is proposed by applying the optimization algorithm along with PTS-TR (Partial Transmit Sequence-Tone Reservation). Grey Wolf optimization is implemented to achieve reduced PAPR. The system is evaluated and simulation results are carried out using MATLAB. The results show that the traditional approach is surpassed by a novel technique.

1. Introduction

The orthogonal frequency division multiplexing (OFDM) is the technique by which digital signal is encoded as a different sub-carriers via orthogonal frequency division. At present, the best way to tackle specific frequency transmissions is done using this method. These canals take place in the vicinity of broadband and multi-paths. 1] The fundamental concept of OFDM is to divide a high-rate information flow into several lower-rate channels that are concurrently transferred through several subcarriers. These subcarriers are mutually overlapping. As the duration of the symbol increases in parallel subcarriers for lower rates, the relative amount of time dispersion is reduced because of multi-path delay. Inter-symbol Interference (ISI) is almost entirely eliminated by incorporating a guard time into each OFDM sign. [2] An extremely elevated value for the peak-to-average energy proportion (PAPR) however is a significant problem with an OFDM scheme. If the high-power amplifier's nonlinearity is lower that PAPR then there are chances of occurring in-band channel disturbance and out-band radiation. The detection effectiveness of the OFDM receptor is therefore very susceptible to nonlinear equipment which is utilized in its signal processing loop, such as Digital to Analog Converters (DAC) and High Power Amplification (HPA), that can seriously impair the system's performance because of spectral regrowth and detection of degraded effectiveness [1] [2]. The alignment of all or most of the subcarriers in a phase leads to the occurrence of a peak in the signal power. Generally, it takes place when the PAPR value is directly proportional, after each symbol period, to the number of carriers. The value of PAPR is computed using the following equation:

$$\boldsymbol{PAPR}(\boldsymbol{dB}) = \mathbf{10}\ \boldsymbol{log}\ (\boldsymbol{N})$$

Where, N is the number of carriers.

A. Factors for selecting the PAPR reduction technique

A number of factors for choosing the technology should be regarded which can efficiently decrease PAPR and retain output with better quality. These following factors are to be considered [[4] as:

The methods to reduce PAPR should be enabled to decrease PAPR without adding in-band distortion and out-of-band radiation.

Low average power: The power increase needs a high linear area in HPA and therefore reduces the efficiency of BER.

No BER efficiency degradation: The purpose for reducing PAPR is to improve system efficiency and BER compared to the original OFDM system.

Addition Power: Efficiency of energy should be taken into account when PAPR is reduced. If more power is needed to implement the method which reduces PAPR, it would result in degraded performance of the BER due to returning of transmitted signals to the original signal.

No spectral spillage: It is important that the PAPR method of reducing the inherent function of orthogonality in the OFDM signal should not be demolished.

Many techniques were suggested for reducing PAPR. Some techniques, such as coding[5], (6], selective mapping with side information (explicit or implicit)[7], (8],[6], or a tone reservation[9]), have been developed on the basis of redundancy. The decreased transmission rate is an important impact of using redundancy in reducing PAPR**.**

2. PPAR Reduction Techniques PAPR

PAPR reduction methods differ in function of the system's requirements and are based on different factors. The variables that are taken into consideration before the adoption of the PAPR scheme method includes the reduction in capacity, increased strength of a signal, loss of the data rate, computation complexity, and an boost in the bit-error rate at the recipient location. [10]. Thus, it is preferable to resolve PAPR by decreasing the peak signal power, using the PAPR suppression methods. Following is the description of methods for reducing PAPR. Figure 1 shows the broad categorization of reduction techniques**.**

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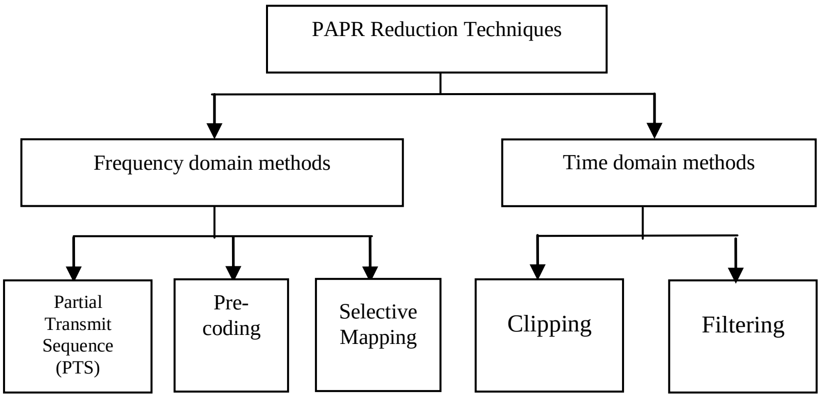

FIGURE 1: **Classification of PAPR reduction methods**

CLIPPING: Clipping is perhaps the simplest procedure for a reduction in PAPR when the signal is clipped above a predetermined threshold level, which entails a distortion of the in band or out-of-band, which may destroy the orthogonality of the subcarriers. For the subsequent windowing of the cut off signal, the value of this amplitude must ideally be as narrow as possible[10,11] An amplitude's threshold value is set in this method, with any sub-carrier with amplitude greater than that set value or sub-carrier being screened to produce a reduced PAPR value.

Pre-coding: If the impact of deformation methods is mitigated by the use of FEC codes, the OFDM is regarded as COFDM to reduce degradation in signal. Basic idea of a N-Signal in this period is that when N-signals are rounded up to signal strength, distinct coding approaches can be implemented such as[12] Cyclic code (CC)[11], Reed-Muller codes[13],[17] Complement Block Coding[CBC], Simple block code[SBC] and Modified Complement Block Coding [MCBC] Reed-Solomon], Simplex code and Simple Odd Parity Code (SOBC).

Partial Transmit Sequence (PTS):

This method divides an input information set of N symbols into disjoints and transmits the signal. The subblock partitioning technique, which divides sub-carriers into various disjoint sub blocks, can also influence efficiency in reducing PAPR in PTS. These are three types of partitioning systems for sub-block, including adjacent, interleaved and pseudo-random partitioning. The PTS method is based on an infinite amount of sub-carriers and any method of modulation.[14] Advantage of PTS is that any modulation system can operates with an unlimited amount of sub-carrier. However, PTS is a complex method to use.

Selective Mapping: The paper published by Bauml, Fischer, and Huber in 1996[15] introduced "select mappings." Among all the methods, SLM is more successful because it does not yet introduce distortions, therefore, PAPR can be significantly reduced. Data frames are translated into several independent frames, and the reduced PAPR is sent to multiply information sequences into random stage sections. These sequences are involved in the converting process.

HYBRID SCHEME: The hybrid scheme optimizes every data block signal by choosing optimal phase rotation. The optimal phase rotation in proposed scheme is determined by taking the adjacent data blocks effect into account, where the data block optimal phase rotation is based on the idea of minimizing signal [16] power between current data block and previous data block. The optimal phase rotation in the proposed approach is obtained from a different way compared with the defined method.

From above mentioned approaches used to reduce PAPR in OFDM are effective. However, Hybrid scheme is most efficient of all and provides better performance but it is a quite complex implementation and also makes the system to operate with low speed.

3. Present Work

As discussed in above section, the traditional approach [16] faces the issue of high complexity and slow speed. Therefore, this study is intended to propose a novel approach for PAPR reduction. For the accomplishment of the novel approach, this study employs the PTS-TR approach and GWO optimization approach. The role of the PTS-TR approach is to develop the all possible sequence sets and GWO in the PTS module so that the desired reduced PAPR could be obtained in the signals. The role GWO is to optimize the sequences and to find out the best suitable sequence set of the signals. Then the tone reservation is applied to the optimized sequences. Then the sequenced signals are transmitted to the destination.

Techniques Used

Techniques used in the proposed work are as follows:

- **PTS (Partial Transmit Sequence):** For each data block signal, the phase rotation operation is implemented independently in the PTS system and it enables the system to reduce PAPR.
- **TR (Tone Reservation):** In the TR scheme, iterative clipping filtering algorithm is usually adopted. The total N sub-carriers(tones) are divided into R peak reduction tones (PRT) and N-R Data Tones. PRT symbols are selected to give the modulation signal a reduced PAPR in the time domain. The PRT's position is recognized by the receiver and sender. Generally, the selection of PRT is done without any subcarrier or null subcarrier.
- **GWO (Grey Wolf Optimization):** The GWO emulates chasing conduct and social hierarchy of grey wolves. Besides the social hierarchy of the grey wolves, hunting in packs is also another appealing act of the grey wolves. The main components in GWO are surrounding the prey, hunting it and

finally attacking it. The GWO algorithm is described briefly with the following steps:

1:Generate initial search agents Gi (i=1, 2,…., n)
2: Initialize the vector's a, A and C
3: Estimate the fitness value of each hunt agent
Gα=the best hunt agent
Gβ=the second best hunt agent
Gδ=the third best hunt agent
4: Iter=1
5: repeat
6: for i=1: Gs (grey wolf pack size)
Renew the location of the current hunt agent using Equation (3.12).
End for
7: Estimate the fitness value of all hunt agents
9: Update the value of Gα, Gβ, Gδ
8: Update the vectors a, A and C
10: Iter=Iter+1
11: until Iter>= maximum number of iterations {Stopping criteria}
12: output Gα
End

Step 9.

4. Methodology

The methodology of proposed work has mentioned in the following steps which are followed to attain PAPR reduction.

Step 1. initially, the signal is generated randomly in the network
Step 2. After generation of the signal, Modulation is performed using BPSK modulation scheme.
Step 3. Here, serial to parallel conversion of signal is performed.
Step 4. On the parallel signals which are generated in previous section, IFFT operation is implemented.
Step 5. After this, cyclic prefix is added to AFM system.
Step 6. In order to reduce PAPR, grey wolf optimization and partial transmit sequence is applied in CP-OFDM
Step 7. Tone reservation is then applied on the obtained output GWO-PTS.
Step 8. Finally, the PAPr value is calculated after performing the above operation and reduced PAPR value is received.

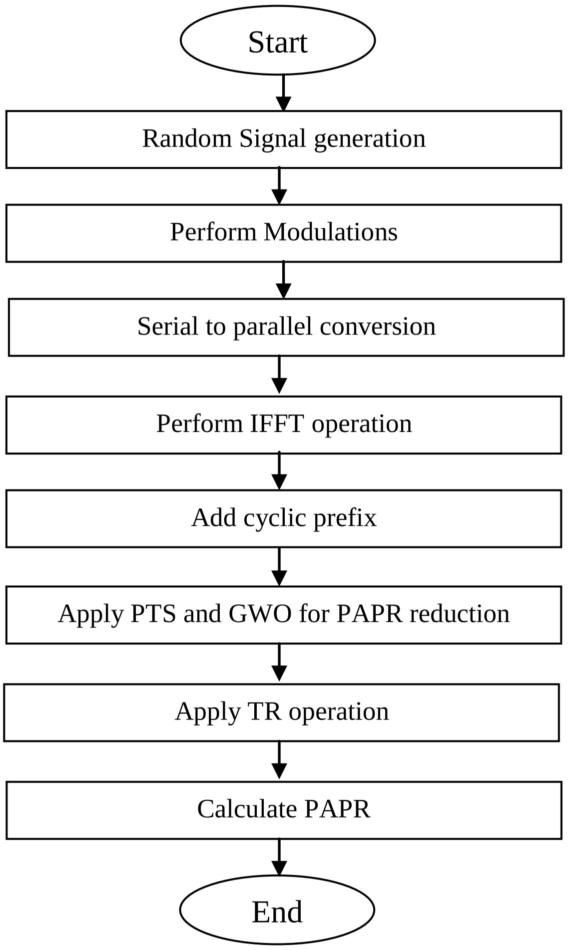

Figure 2: Block diagram of proposed scheme

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5. Results and Discussion

In this paper, a novel scheme is proposed in order to reduce the PAPR value in the network. Along with this, PTS-TR (Partial Transmit Sequence-Tone Reservation) approach for PAPR reduction is analyzed and is optimized using GWO (grey Wolf optimization). Evaluation of system is performed and simulation results are carried out using MATLAB. The results are of proposed work are also compared with traditional approach [16] and various schemes.

Figure 3 represents the results of BPSK modulation in the existing system. In the graph, CCDF curve is presented with the peak value at 11.7393 dB at CCDF 10^{-3} which have impact on the computation efficiency.

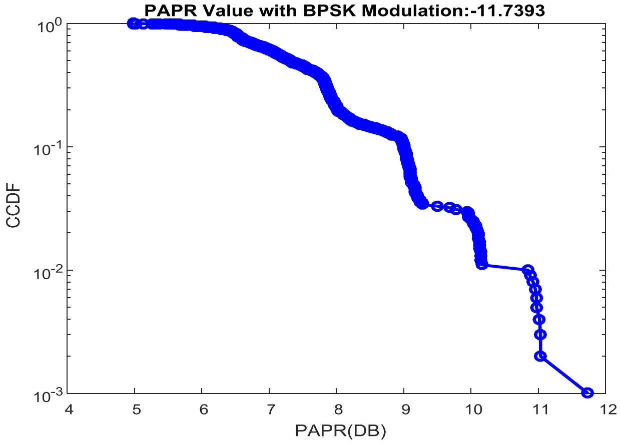

Figure 3: PAPR reduction with BPSK modulation in traditional system.

The simulation results of proposed work are shown in figure 4. GWO algorithm makes this approach more efficient as the PAPR is reduced by a difference of 5.0977 at CCDF $10^{-3.}$ Using Grey Wolf optimization with PTS-TR, reduced PAPR value is obtained.

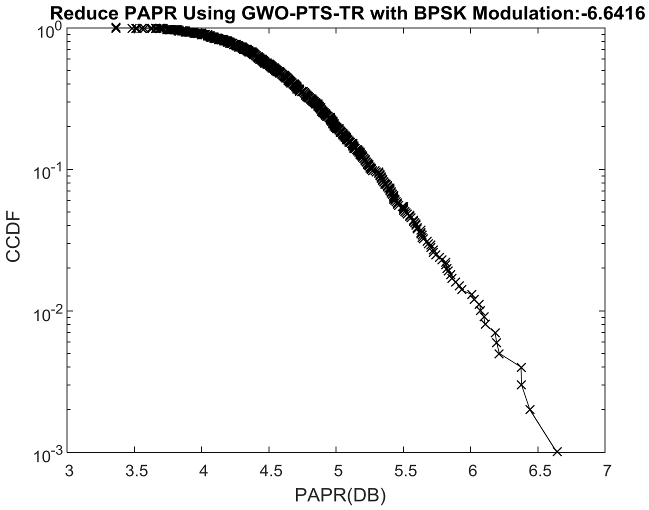

Figure 4: PAPR reduction with the proposed scheme (GWO-PTS-TR) using BPSK modulation.

Comparative analysis of proposed scheme with normal-OFDM is performed during the simulation of the schemes. The graph in figure 5 shows that using PTS is more effective as compared to the scheme in which normal-OFDM is used.

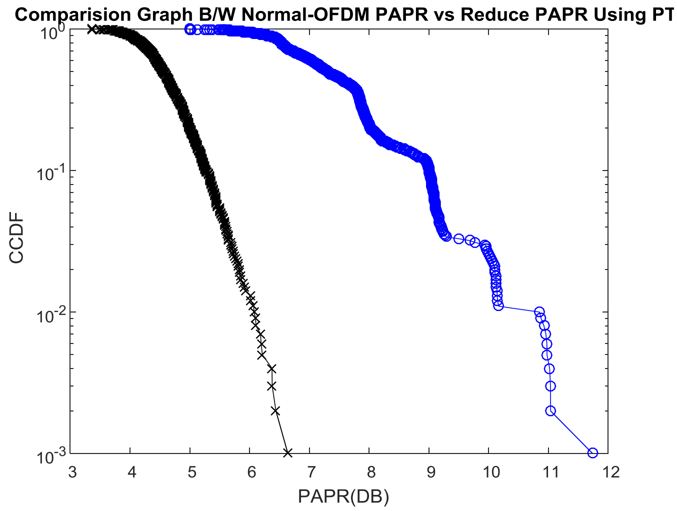

Figure 5: comparison of PAPR reduction with proposed scheme (GWO-PTS-TR) and Normal-OFDM

Figure 6 shows the comparison of proposed GWO-PTS-TR system with various schemes (original scheme, hybrid and M-hybrid) for PAPR reduction. The values of hybrid and M-Hybrid technique for PAPR reduction are 7 dB and nearly 7.3 dB respectively. It shows that proposed scheme outperformed all the previously available techniques by achieving low PAPR value.

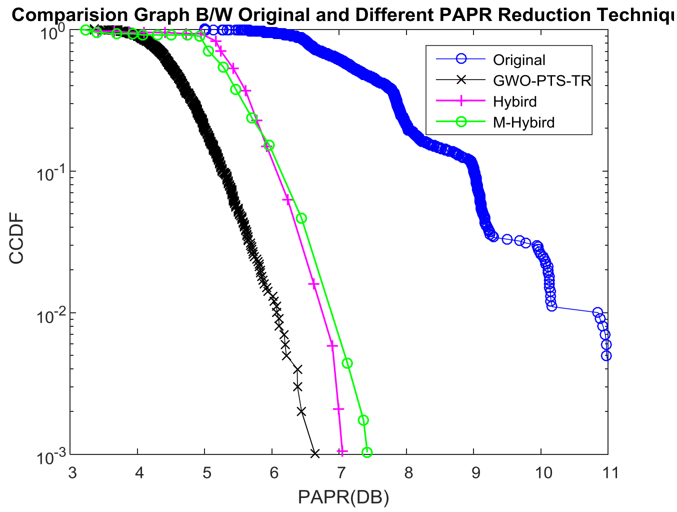

Figure 6: Comparison of PAPR reduction with the proposed scheme (GWO-PTS-TR) using different reduction techniques

6. Conclusion

In this paper, a novel system is proposed for PAPR reduction for efficient system in order to increase the capacity, reduce data loss increase the signal strength and thus to reduce the complexity in the computation. Before proposing the approach, various schemes for PAPR reductions are analyzed. In developing this mechanism, Grey Wolf optimization is applied to the PTS-TR scheme [16]. Simulation is performed with the help of software tool-MATLAB. The simulation results show that effectiveness of the proposed system. The performance of the existing system is outperformed using the novel technique.

In future, PAPR reduction technique can be improved by using different optimization methods.

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