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SLM APPROACH FOR PAPR REDUCTION IN OFDM SYSTEMS VIA GENETIC ALGORITHM

Ch. Manvitha Lakshmi[*1] & Mr. M. Srininasa Rao[2]
[*1]PG Student (DECS),Department of ECE, QIS College Of Engineering and Technology (Autonomous), India
[2]M.Tech (Ph.D), Department of ECE, QIS College of Engineering and Technology (Autonomous), India

ABSTRACT

Orthogonal frequency division multiplexing (OFDM) has lately used in wireless communication systems for its high transmission data rate and robustness against frequency selective fading. However, OFDM system suffers from a major drawback at the transmitter that is the high peak-to-average power ratio (PAPR) of the transmitted OFDM signal. An SLM (Selected Mapping) is an effective algorithm to reduce PAPR (Peak to Average Power Ratio) in OFDM (orthogonal frequency division multiplexing) signal without distortion. However the SLM scheme needs to dispose U paths of IFFT (Inverse Fourier Transform), which increases the computational burden and reduces the signal transmission rate. This paper offers an improved algorithm that based on Genetic Algorithm. The proposed algorithm executes the selection before the IFFT module and only selects one sequence with the highest randomness to be transmitted. Because only one path of signal is transmitted in IFFT modules, the proposed algorithm has lower complexity compares with SLM. Simulation results indicate that the proposed method obtains desirable PAPR reduction performance with low computational complexity.

Keywords*:* *Orthogonal Frequency Division Multiplexing (OFDM), Peak-to-Average Power Ratio (PAPR), Selected mapping (SLM), Genetic Algorithm (GA).*

I. INTRODUCTION

OFDM is an operative multicarrier wireless system for transmission of high rate over frequency selective fading channels [1]. OFDM has been widely used in many wireless communication standards [2], [3]. The basic concept of OFDM is to divide a high rate serial data into parallel lower rate streams that are transmitted simultaneously via multiple narrowband orthogonal sub-carriers. Consequently, OFDM converts a frequency selective channel into a parallel collection of frequency flat sub channels, where only simple equalizers are needed. However, OFDM introduces intersymbol interference (ISI) and intercarrier interference (ICI). But these problems can be reduced by introducing the cyclic prefix (CP). However, the CP has the disadvantage of reducing the spectral efficiency [4].

In general, OFDM signal is a sum of many data modulated subcarriers and in the worst case they may all added constructively to give a very large peaks resulting in a large PAPR which is a major drawback of the OFDM system. The high PAPR distorts the OFDM signal when passing into a power amplifier. Conventional solution to reduce the PAPR is to use a very large linear amplifier range, which increases system complexity and system cost [5], [6].

Recently, various PAPR reduction techniques have been proposed such as tone reservation (TR) technique [7], [8], partial transmit sequence (PTS) technique [9], and SLM technique [10]. The conventional SLM technique is an attractive and efficient technique, since it can achieve a good PAPR reduction without signal distortion.

In order to improve PAPR performance of OFDM, IFFT/FFT block is replaced by the wavelet transform in WOFDM system to achieve better PAPR reduction performance. Moreover, WOFDM system has better spectrum efficiency and lower bit error rate (BER) compared to the conventional OFDM under certain conditions [11], [12].

In this paper, the SLM-WOFDM is used to reduce the PAPR, and then GA is applied to SLM-WOFDM for searching the optimum phase rotation factors leading to more improvement in PAPR reduction performance.

The paper is structured as follows: Section II briefly shows the OFDM signal model and the PAPR problem. In section IV, the conventional SLM-OFDM is described. GA based SLMOFDM is proposed in section V. Then, the simulation results are presented in section VI. Finally, conclusions are drawn in section VIII.

II. BACKGROUND

OFDM is one of the most efficient multicarrier modulation techniques. Which provides high spectral efficiency, low implementation complexity, less vulnerability to echoes and non – linear distortion? Due to these advantages of the OFDM system, it is vastly used in various communication systems. The major problem faced by implementing this system is the high peak – to – average power ratio. A large PAPR increases the complexity of the analog – to – digital and digital – to – analog converter and reduces the efficiency of the radio – frequency (RF) power amplifier. Some applications are implemented to reduce the peak powers transmitted which in turn reduces the range of multicarrier transmission. This leads to the prevention of spectral growth and the transmitter power amplifier is no longer confined to linear region in which it should operate. This produces a harmful effect on the battery lifetime.

Numbers of techniques are introduced to deal with the problems of PAPR. Some of them are 'amplitude clipping, 'clipping and filtering', 'coding', 'partial transmit sequence (PTS)', 'selected mapping (SLM)' and 'interleaving'. These techniques achieve PAPR reduction at the expense of transmit signal power increase, bit error rate (BER) increase, data rate loss, computational complexity increase, and so on.

A) Peak – to – average power ratio

In an OFDM, large number of independent modulated sub-carriers is present. Due to this the peak value of the system can be very high as compared to the average of the whole system. The ratio of the peak to average power value is termed as Peak-to-Average Power Ratio. Coherent addition of N signals of same phase produces a peak which is N times the average signal.

The major disadvantages of a high PAPR are-

1. Increased complexity in the analog to digital and digital to analog converter.
2. Reduction is efficiency of RF amplifiers.

B) Papr of a multicarrier signal

Let the data block of length N is represented by a vector= $[X_0,X_1,....,X_{N-1}]^T$. Duration of any symbol X_k in the set X is T and represents one of the sub – carriers $\{f_n,n = 0,1,...,N - 1\}$ set. As the N sub – carriers chosen to transmit the signal are orthogonal to each other, so we can have $f_n = n\Delta f$, where $n\Delta f = 1/NT$ and NT is the duration of the OFDM data block X. The complex data block for the OFDM signal to be transmitted is given by

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

C) Cumulative distribution function

The Cumulative Distribution Function (CDF) is one of the most regularly used parameters, which is used to measure the efficiency of any PAPR technique. Normally, the Complementary CDF (CCDF) is used instead of CDF, which helps us to measure the probability that the PAPR of a certain data block exceeds the given threshold.

By implementing the Central Limit Theorem for a multicarrier signal with a large number of sub-carriers, the real and imaginary part of the time – domain signals have a mean of zero and a variance of 0.5 and follow a Gaussian distribution. So Rayleigh distribution is followed for the amplitude of the multicarrier signal, where as a central chi-square distribution with two degrees of freedom is followed for the power distribution of the system.

The CDF of the amplitude of a signal sample is given by

$$F(z) = 1 - exp(z)$$

The CCDF of the PAPR of the data block is desired is our case to compare outputs of various reduction techniques. This is given by

$$P(PAPR > z) = 1 - P(PAPR \leq z)$$
$$= 1 - F(z)^N$$
$$= 1 - (1 - exp(-z))^N$$

III. LITERATURE REVIEW

A. Joint ICI Cancellation and PAPR Reduction in OFDM systems without side information [13].

In this paper, researchers have proposed the mathematical analysis of PAPR performance for ICI self-cancellation, new ICI self-cancellation and ICI conjugate cancellation schemes. It demands the requirement of PAPR reduction because PAPR performances of these schemes are either very nearer to or poorer than the OFDM signal. Here in this paper, researchers has introduced a multipoint partial transmit scheme (PTS), which progress the PAPR performance the PAPR performance of the ICI cancellation scheme.

B. An SDP approach for PAPR reduction in OFDM using partial transmit sequence [14].

The Partial transmit sequence algorithm has been broadly used to lessening the influence of peak to average power ratio in OFDM system. The important phase in PTS is the practice of a finite set of phase factor "bv" to rotate the data or information signal before transmission to decrease the effect of PAPR. In this paper, researchers propose a semi definite programming which discoveries the optimal set of phase rotation factors recycled in the PTS technique.

C. Reduction of PAPR in OFDM system by intelligently applying both PTS and SLM algorithm [15]

In OFDM system PAPR is the key problem. Selective mapping and partial transmit sequence (PTS) existing scheme are effective, but on the other hand it is very hard to gadget due to the high complication. The characteristic algorithm in this research area is the multi-time clipping algorithm SLM algorithm, PTS algorithm and golay complement sequence algorithm. In this paper, researcher found that both SLM and PTS algorithm have good performance in dropping the PAPR than the golay complement sequence algorithm than the clipping algorithm. Thus a new PAPR reduction algorithm is offered, by using both PTS and SLM algorithm, which tries lessen the PAPR problem.

D. Partial Transmit Sequence for PAPR reduction of OFDM signals with Stochastic Optimization technique [16].

A high PAPR is a major drawback in orthogonal frequency division method. The conventional PTS technique is very effective in PAPR reduction in OFDM, but the complexity is more in practical. To diminish the complexity still improving the PAPR statistics. So in this paper, researchers has presented a stochastic optimization technique to lessen the PAPR of an OFDM system.

IV. SELECTIVE MAPPING TECHNIQUE (SLM)

The hypothesis behind SLM is to represent the data blocks at the transmitter by different data blocks which all contain the same information as the original. These new data blocks results subsequent to increasing the first information obstruct by a grouping of stages produced at the transmitter. At that point the basis of which information obstruct among others ought to be chosen for transmission is to pick the one which gives the most minimal PAPR [8, 9]. SLM square graph is appeared in Fig. 4.

The SLM scenario is summarized as;

1. The transmitter produces F unique phase sequences whose length is L
2. The first information piece is duplicated by these F stage arrangements to produce F remarkable representations of the unique information piece.
3. The Inverse Fast Fourier Transform (IFFT) is connected on each of these adjusted information hinders as it is appeared.

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4. Finally, the changed information piece which gives the most minimal PAPR is chosen for transmission. At the beneficiary side, with a specific end goal to recover the first information, side data ought to be sent from the transmitter to educate the beneficiary which stage succession has been chosen for transmission.

In the SLM system, the transmitter produces an arrangement of adequately distinctive hopeful information hinders, all speaking to the same data as the first information square, and chooses the most great for transmission [30, 31]. A piece outline of the SLM strategy is appeared in Fig. 4. Every information piece is duplicated by U distinctive stage arrangements, each of length N, B(u) = [bu,0 , bu,1 , … , bu,N–1] T , u= 1, 2, … , U, bringing about Unmodified information squares. To incorporate the unmodified information hinder in the arrangement of changed information squares, we set B(1) as the every one of the one vector of length N. Give us a chance to signify the changed information obstruct for the u th stage arrangement X(u) = [X0bu,0 , X1bu,1 , … , XN–1bu,N–1] T , u= 1, 2, … , U.

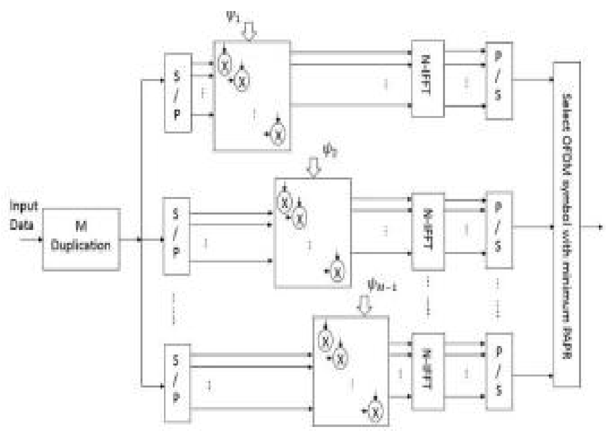

Fig 1: Functional block diagram of the SLM technique.

Among the altered information squares X(u) , u= 1, 2, … , U, the one with the least PAPR is chosen for transmission. Data about the chose stage grouping ought to be transmitted to the recipient as side data. At the collector, the reverse operation is performed to recuperate the unique information piece.. This methodology is material with a wide range of regulation and any number of subcarriers.

V. PROPOSED GA BASED SLM-OFDM SYSTEM

This section investigates how GA can be used for phase optimization of SLM-OFDM system. In order to solve the optimization problem of this system and acquiring more PAPR reduction, the proposed technique uses GA as the selection mechanism of phase rotation factors for SLMOFDM system. GA, which is a search heuristic algorithm based on the process of natural evolution, can find a good solution for optimization problems by evolving the population of solutions with genetic operators such as selection, mutation and crossover [15]. The block diagram of the proposed GA based SLM- OFDM system is shown in Figure 3.

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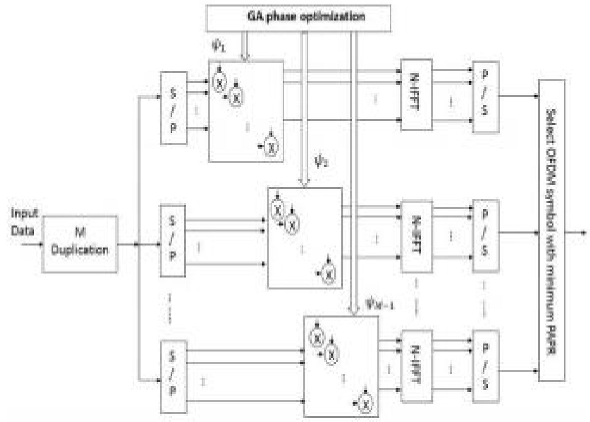

Fig 2: Functional block diagram of the proposed GA based SLMOFDM technique.

In order to employ the GA method to find the optimum phase factors that minimize the PAPR in the SLM-OFDM system, the following optimization problem is required to be solved:

$$\psi_{opt} = argmin_{\psi} \left\{ \frac{max_{0\leq n\leq N-1} |x_m(n)^2|}{E\{|x_m(n)^2|\}} \right\} \quad (1)$$

Where $m = 1,2,......M$ and ψ_{opt} is the optimum phase rotation factor? The selection mechanism of GA based SLM-OFDM is described as follows:

Proposed Algorithm: GA-SLM-OFDM method

1. Select the first population size, the mutation probability, crossover probability, and initial population randomly. Each gene represents a vector of phase factor candidate.
2. Calculate the PAPR value for each gene by multiplying X with the set of phase rotation factors as given by (6).
3. Select genes with smallest PAPR value (called set of parents).
4. Crossover and mutate all genes to generate a new genes (offsprings).
5. Go back to step 2 using the new generated population. The processing is repeatedly executed until termination (maximum number of generation). The vector of phase rotation factors with the lowest PAPR are used for the transmitted data and sent to the receiver.
6. End

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VI. SIMULATION RESULTS

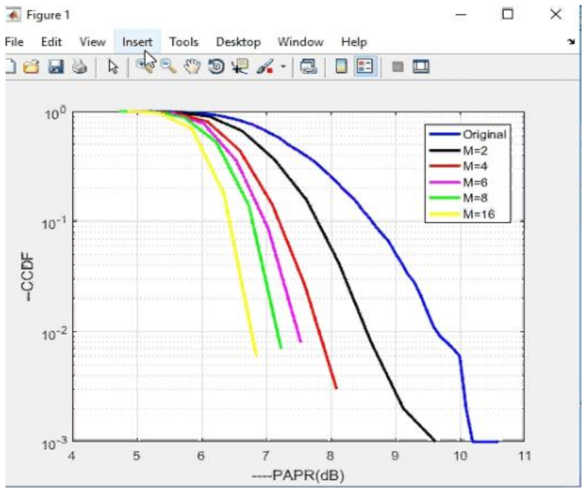

Fig 3: CCDF of the OFDM for SLM technique with different number of phase sequences

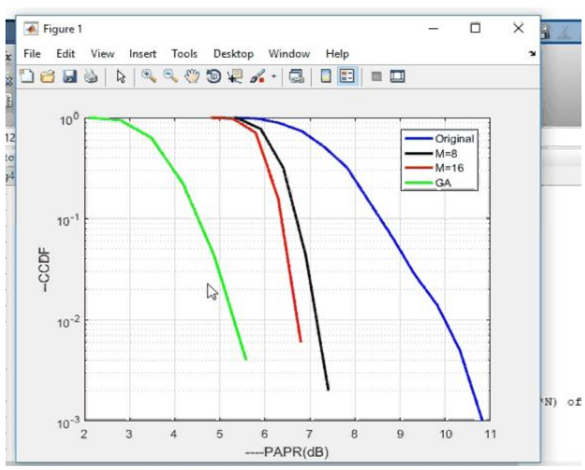

Fig 4: CCDF of the original OFDM, GA based OFDM-SLM and OFDM-SLM techniques

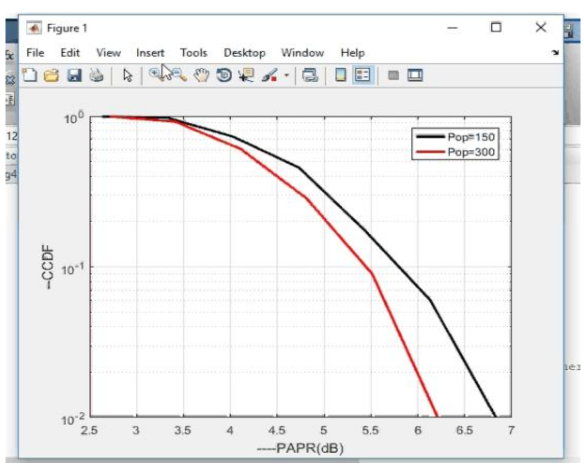

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Fig 5: CCDF of the GA based OFDM-SLM technique with different population size P.

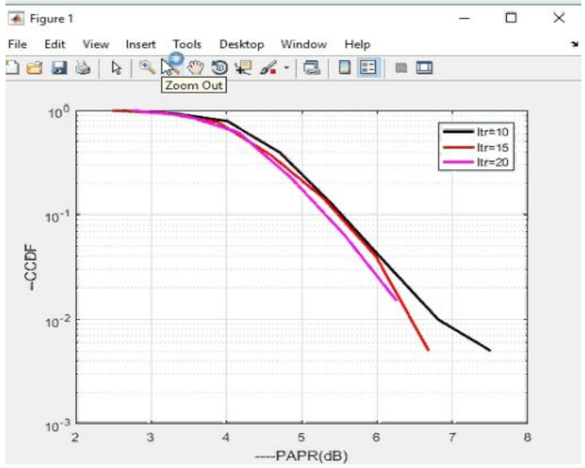

Fig 6: CCDF of the GA based OFDM-SLM technique with different iteration values.

VII. DISCUSSION

Some other papers work on optimization for the candidate vectors of phase rotation to PTS technique using variable to variable crossover in genetic algorithm study optimum solution searching for trade off PAPR reduction in OFDM systems and cost of calculation with increasing the number of sub-blocks, my work in genetic algorithm make tournament selection with single-point crossover and boundary mutation but with less sub-blocks than other papers and work directly on the OFDM signal with increasing one condition when plotting if there is consecutive (10) output PAPR are (0) then the code will change these values randomly with another PAPR result as not to be ten values equal 0 consecutive so my work care only for PAPR reduction values.

VIII. CONCLUSION

This paper proposes an improved algorithm GA-SLM which is based on SLM. The simulation results predict that the new algorithm is effective in reducing the PAPR of OFDM system. Though its PAPR performance is a little worse than the SLM scheme, this new algorithm can reduce complexity of OFDM system greatly.

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