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An Improvement in Peak-to-Average Power Reduction Using Subspace Carrier Genetic Algorithm in OFDM

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Abstract :- The orthogonal frequency division multiplexing (OFDM) is an attractive transmission technique for high bit-rate communication systems. OFDM has become a promising candidate for high performance 4G broadband wireless communications. One of the main disadvantages of OFDM is the high peak-to-average power ratio (PAPR) of the transmitter's output signal. Selected-Mapping (SLM) with Genetic scheme which does not require the transmission of side information and can reduce the peak to average power ratio (PAPR) in turbo coded orthogonal frequency division multiplexing (OFDM) system is proposed. Simulation results show that the system can achieve significant reduction in PAPR and satisfactory bit error rate performance over AWGN channels.

Keywords: *Orthogonal Frequency Division Multiplexing (OFDM), Selective Mapping (SLM), peak-to-average-power-ratio (PAPR), Complementary Cumulative Distribution Function (CCDF), Bit Error Rate (BER).*

I. INTRODUCTION

Orthogonal frequency division multiplexing (OFDM) is a standout between the most appealing candidates for fourth era (4G) remote correspondence frameworks. OFDM offer high spectral efficiency, resistant to the multipath delay, low between image obstruction (ISI), insusceptibility to recurrence specific blurring and high power productivity. Because of these benefits OFDM is picked as high information rate correspondence frameworks. However OFDM framework experiences major issue of high PAPR. In OFDM framework yield is superposition of numerous sub-bearers. For this situation some immediate power yield may increment extraordinarily and turned out to be far higher than the mean energy of framework. To transmit signals with high PAPR, it requires control intensifiers with high power scope. These sorts of speakers are extremely costly and have low effectiveness cost. In the event that the pinnacle power is too high, it could be out of the extent of the straight power enhancer. This offer ascends to non-straight twisting which changes the superposition of the flag range bringing about execution corruption.

PAPR can be depicted by its correlative combined dispersion work (CCDF). Numerous PAPR decrease technique have been proposed, for example, cutting strategy, coding technique, specific mapping (SLM) strategy, Partial transmit sequence (PTS). Cutting strategy cut the crest over a specific recommended level. The value of this cut-out strategy is that PAPR can be effectively diminished. Be that as it may, the BER execution turns out to be more regrettable because of many absconded signals. Piece coding is another essential technique for PAPR lessening. This technique can lessen the PAPR with no flag twisting. In any case, the code rate winds up noticeably littler than one, so that transfer speed effectiveness is exceptionally poor.

The SLM and PTS might be arranged into the stage control plan to get away from the high pinnacle. In SLM, one flag of the least PAPR is chosen an arrangement of a few signs containing similar data information. In PTS, the least PAPR flag is made by ideally stage consolidating the flag sub-pieces. Both systems are exceptionally adaptable plan and have a compelling execution of the PAPR decrease with no flag bending. We propose to amplify twisting less SLM-GA system which enhances PAPR by including little repetition.

II. OFDM SYSTEM

OFDM signifies a different system design methodology. It can be supposed of as a combination of modulation and multiple-access schemes that segments a communications channel in such a manner that various users can share it. Whereas TDMA segments are agreeing to time and CDMA segments are agreeing to spreading codes, OFDM segments are agreeing to frequency. It is a technique that splits the spectrum into a number of equally spaced tones and conveys a ration of a user's data on each tone. A tone can be supposed of as a frequency, greatly in the same way that each key on a piano characterizes a unique frequency.

OFDM can be observed as a form of frequency division multiplexing (FDM), however, OFDM has an significant special property that each tone is orthogonal with every other tone. FDM usually requires frequency guard bands between the frequencies so that they do not interfere with each other. OFDM permits the spectrum of each tone to overlap, and because they are orthogonal, they do not interfere with each other. Fig 1 Shows OFDM system

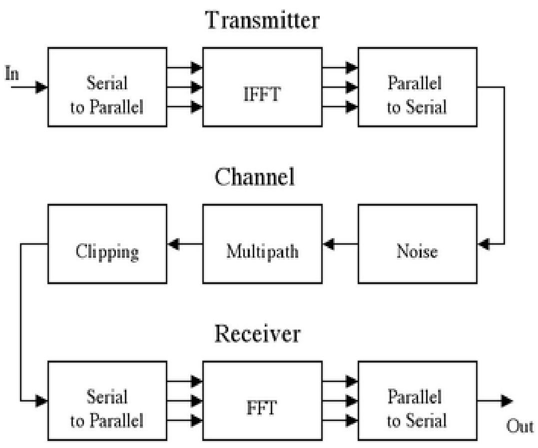

Fig 1 OFDM System

By permitting the tones to overlap, the complete amount of spectrum required is reduced. OFDM is a modulation technique in that it allows user information to be modulated onto the tones. The information is modulated onto a tone by correcting the tonse's phase, amplitude, or both. In the most simple form, a tone may be present or restricted to indicate a one or zero bit of information; however either phase shift keying (PSK) or quadrature amplitude modulation (QAM) is typically engaged. An OFDM scheme takes a data stream and ruptures it into N parallel data streams, each at a rate 1/N of the original rate. Each stream is then mapped to a tone at a irreplaceable frequency and combined together using the inverse fast Fourier transform (IFFT) to yield the time domain waveform to be transmitted.

A. PAPR

The highest factor or peak-to-average ratio (PAR) or peak-to-average power ratio (PAPR) is a measurement of a waveform, deliberate from the peak amplitude of the waveform divided by the RMS value of the waveform. High peak-to-average-power ratio (PAPR) has been mentioned as one of the weaknesses of OFDM modulation format. The transmitted time-domain waveform for one OFDM symbol can be written as

$$s(t) = \sum_{k=1}^{N_{sc}} c_k \, e^{j2\pi f_k t} , \qquad f_k = \frac{k-1}{T_s} \tag{1}$$

The PAPR of the OFDM signal is defined as

$$PAPR = \frac{\max\{|s(t)|^2\}}{E\{|s(t)|^2\}} , \qquad t\epsilon[0, T_s] \tag{2}$$

B. SLM Technique

Selective Mapping (SLM) is used for reducing of peak to average transmit power of multicarrier transmission system with selected mapping. A comprehensive set of candidate signal is generated signifying the similar information in selected mapping, and then regarding the most satisfactory signal is selected as consider to PAPR and transmitted. In the SLM, the input data configuration is multiplied by random series and resulting series with the lowest PAPR is selected for transmission. To let the receiver to recuperate the actual data to the multiplying sequence can be sent as 'side information'.

The CCDF of the actual signal sequence PAPR above threshold PAPR0 is written as Pr{ PAPR > PAPR0 }. Thus for K statistical autonomous signal waveforms, CCDF can be written as [Pr{ PAPR > PAPR0 }]R so the probability of PAPR surpass the same threshold. The probability of PAPR greater than a threshold Z can be written as

$$P(PAPR<Z) = F(Z)^N = (1 - \exp(-Z))^N \tag{3}$$

In selection mapping method, firstly M statistically autonomous sequences which represent the same information are generated, and next, the resultant M statistically independent data blocks

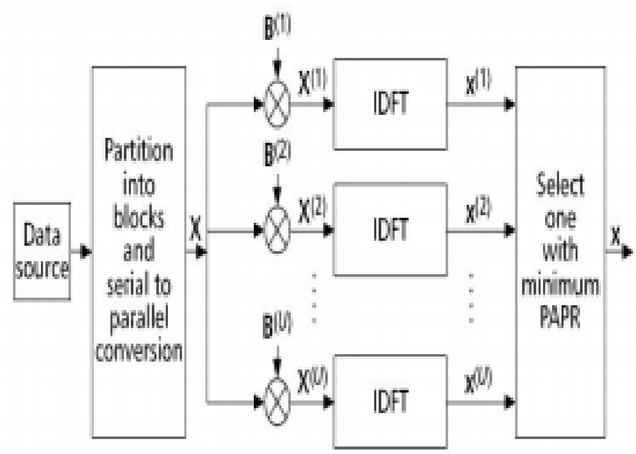

Fig 2: Selective Mapping Technique

II. PROBLEM STATEMENT

In OFDM system, the output is the superposition of multiple sub-carriers. In this case, certain instantaneous power outputs might increase impressively and become far developed than the mean power of the system when the phases of these carriers are similar. This is also clear as great Peak-to-Average Power Ratio (PAPR). High PAPR is one of the most thoughtful problems in OFDM system. To transmit signals with high PAPR, it needs power amplifiers with very high power possibility. These types of amplifiers are very costly and have low efficiency-cost. If the peak power is too high, it could be out of the opportunity of the linear power amplifier. This gives increase to non-linear distortion which variations the superposition of the signal spectrum resulting in presentation degradation. If there are no measures to decrease the high PAPR, OFDM system could face severe limitation for practical applications. To conflict high PAPR, one instinctive solution is to accept amplifiers to have higher trade-off range. However, these sorts of amplifiers are generally costly and have low efficiency cost, and therefore are of no practical usage. On the other side, assured algorithms were familiarized and been proved have a decent performance of high PAPR reduction. Hence, in this paper, some presently promising PAPR reduction techniques are premeditated and compared. The performance of these reduction arrangements are appraised by using simulation software, Matlab.

III. SYSTEM MODEL

In edict to achieve more effective fall in PAPR, the SLM scheme would select one sequence after IFFT modules, thus it need N IFFT modules, which creates system highly complex. According to [8], the more random the sequence is, the smoother the frequency spectrum will come to be. Thus in edict to decrease the complication of this system, we propose an upgraded algorithm which is baptized Selective Mapping with Genetic Algorithm. This pattern selects one sequence with the finest randomness before IFFT modules, thus only one IFFT module is essential, redeemable the complexity of the system. The principle of GA-SLM can be uttered as followed:

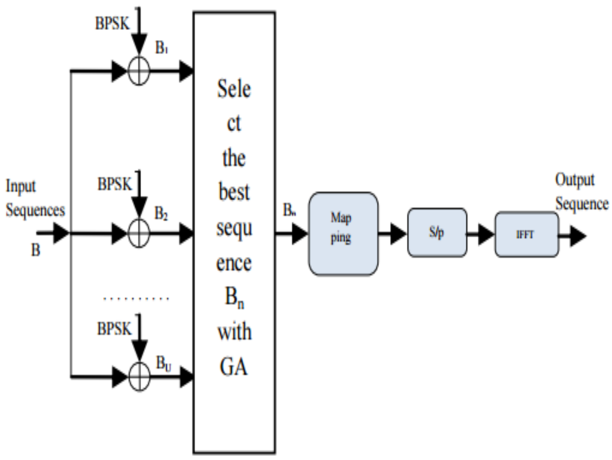

Figure 3: Block diagram of GA-SLM principle

The specific procedure of the GA-SLM arrangement is signified as followed. Suppose the input random sequence B is:

$$B = (x_1, x_2, x_3,.......,x_N) \tag{4}$$

Where the number of subcarriers is N, x_n ($1 \leq n \leq N$), which is either 0 or 1. The BPSK is approved to modulate the input signal sequences as:

$$B = (x_{n,1}, x_{n,2}, x_{n,3},......., x_{n,N}) \ (1 \leq n \leq U) \tag{5}$$

Bn is collected of 1 and -1, GA-SLM selects one sequence which has the finest randomness as the output. In this arrangement the key point is judge the amount in randomness of the arrangement:

1. Adjudicating the nature of randomness of Bn sequences. The closer the number of 1 and -1 is, the more random the sequence is, assuming:

$$S_n = \sum_{i=1}^{N} x_{n,i} \quad (1 \leq n \leq U) \tag{6}$$

Where Sn> 0 signifies the numbers of 1 that is larger than -1, Sn< 0 stands for the opposed situation. The Sn procedures 0, the randomness of the sequence increases.
2. Adjudicating the numbers of Bn sequence's oscillation which is totaling the number of sequence's changes first, and then match it with half of the sequence's width. Supposing:

$$T_n = \sum_{i=1}^{N-1} \left| \frac{x_{n,i+1} - x_{n,i}}{2} \right| - \frac{N}{2} \quad (1 \leq n \leq U) \tag{7}$$

Then when the T_n is lesser, the nature of random of the sequence is improved.

3. Eliminating the sequences that have a lesser period, As the sequences with small period usually have a great PAPR, we want to ignore them, supposing:

$$W_{n,1} = \sum_{k=1}^{N-2} x_{n,k}, x_{n,k+2} \quad (1 \leq n \leq U) \tag{8}$$

$$W_{n,2} = \sum_{k=1}^{N-3} x_{n,k}, x_{n,k+3} \quad (1 \leq n \leq U) \tag{9}$$

A. Genetic Algorithm

Genetic algorithm is a part of evolutionary computing, which is a speedily rising area of artificial intelligence. We can see that, genetic algorithm is enthused by Darwin's theory about evolution. Just said, explanation to a problem solved by genetic algorithm is progressed.

In a genetic algorithm, a population of strings (called genes or the genotype of the genome), which encode candidate solutions (called individuals, creatures, or phenotypes) to an optimization difficult, is progressed toward good solutions. Usually, solutions are signified in binary as strings of 0s and 1s, but other encodings are also promising. On the basis on this idea we substitute the calculation and offer all signals to Genetic Algorithm as input so that augmented signal will have least possible randomness which defini on the basis of Sn ,Tn ,$W_{N,1}$ and $W_{N,2}$ parameter thus at the end it will get selected for further handling.

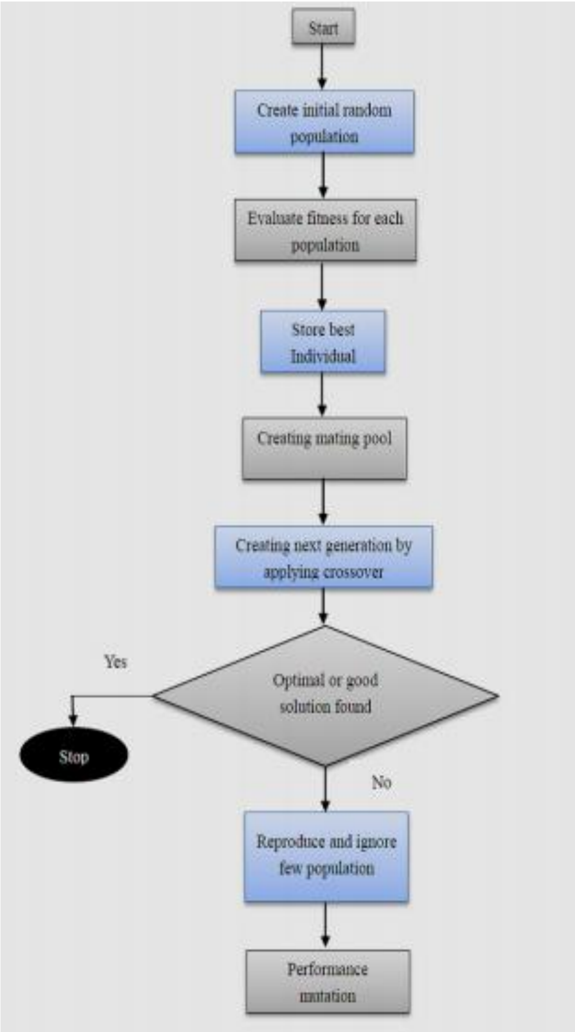

Figure 4: Flow chart of GA

IV. PROPOSED IMPLEMENTATION

This paper proposes an enhanced algorithm GA-SLM which is established on SLM. The simulation outcomes forecast that the new algorithm is effective in plummeting or reducing the PAPR of OFDM system. Though its PAPR performance is a slight poorer than the SLM scheme, this new algorithm can reduce complication of OFDM system greatly.

In the proposed method, the surviving estimated channel is randomly mutated by GA, and the finest channel matrix is identified based on the fitness function which is given as

$$\text{Fitness} = [(H-HL)/H]^{2} \quad (8)$$

where H is the reference channel. Then, MSE is calculated for the above channel. The same steps are implemented for repeated number of iterations. Similarly, FFT- estimated channel is randomly mutated by GA, and the finest channel matrix is selected based on the fitness function and also MSE is calculated. The fitness function is given as

$$\text{Fitness} = [(H-HMMSE)/H]^{2} \quad (9)$$

A. Steps To Execute Genetic Algorithm

- Creates the process of the algorithm by priming a random initial population which is a set of potential explanations or points in the search space.
- Calculates the fitness value of each member or specific of the current population in order to create new community or generation.
- On the basis of fitness value, choice for members called genesis or parents takes place.
- Some of the individuals having lesser fitness values deliberated as Elite that are approved straight to the next generation.
- Genetic solution replica depends upon two operatives that are Crossover and Mutation.
- Crossover promises the algorithm to appraise the best genes from discrete individuals and then recombined them to have improved average fitness value. It generates a possibly superior progenies for the next generation.
- Mutation applies random changes to an individual in the current generation that will offer genetic diversity. It also allows algorithm to examine over a broader space for sinking the untimely convergence that causes tricking of algorithm in global minima.
- Replaces the current population with the progenies to generate the next generation.

B. Mathematical Expression Of Papr

In the OFDM modulation procedure, a block of N data symbols is designed with each symbol modulating the equivalent subcarrier from a set of subcarriers. The transmitter block diagram is exemplified in Fig. 1 where the inward data is first modulated by using QPSK modulation. The transmitted OFDM signal for complex data block is given by equation

$$x(t) = \frac{1}{\sqrt{N}} \sum_{n=0}^{N-1} X_n e^{j2\pi n f_o t}, 0 \le t \le T \quad (10)$$

The discrete OFDM signal, by replacing $t = kT_b$ where $T_b = T/N$, is expressed as

$$x(t) = \frac{1}{\sqrt{N}} \sum_{n=0}^{N-1} X_n e^{j2\pi kn/LN}, k = 0,1,\ldots, NL-1 \quad (11)$$

The PAPR of the transmitted signal is given by equation.

$$PAPR = \frac{\max_{0\le t\le T} |x(t)|^2}{\frac{1}{T}\int_0^T |x(t)|^2 dt} \quad (12)$$

The central limit theorem makes the real and imaginary values of x(t) becomes Gaussian distributed with the supposition that N is very bulky. The amplitude of the OFDM signal therefore has the Rayleigh distribution with

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zero mean and a variance of N times the variance of one intricate sinusoid. Normally, the Complementary Cumulative Distribution the CCDF of the PAPR of a data block with Nyquist rate sampling is agreed by equation [15]

$$P = P_r\left[PAPR\{x(n)\} > PAPR_0\right] = 1 - \left(1 - e^{-PAPR_0}\right)^N \tag{13}$$

The CCDF of PAPR calculated of the L-time oversampled OFDM signal can be modified as

$$P = P_r\left[PAPR\{x(n)\} > PAPR_0\right] = 1 - \left(1 - e^{-PAPR_0}\right)^{LN} \tag{7}$$

V. RESULT

The simulation of PAPR OFDM with subcarrier space method is done by using MATLAB software. The result is centered on the BER and probability of error. This Investigational results displays how to use the Complementary Cumulative Distribution Function (CCDF) System thing to measure the probability of a signal's instantaneous power being larger than a specified level over its average power in phase sequence with sub carrier also define m-QAM measurement modulation technique relatively to other modulation such as BPSK and etc. Construct the CCDF object, enable the PAPR output port, and set the maximum signal power limit to 50 dBm.

Create a 16-QAM modulator and 64-QAM modulation on OFDM modulator. The QAM modulated signal will be evaluated by itself and evaluated again after OFDM modulation is applied.

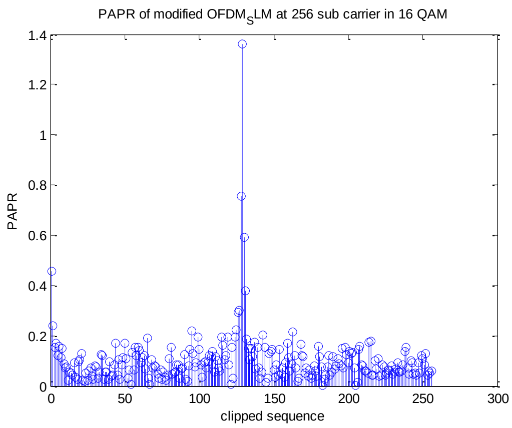

Figure 5: PAPR of normal OFDM SLM technique at 256 sub carrier in 16 QAM

We have considered normal OFDM system with N = 256 subcarriers on 16 QAM and transmission of 300 OFDM symbols to evaluate the overall performance of the OFDM SLM system. All the simulations are carried out and plots of theoretical results are evaluated in MATLAB environment.

We have used PAPR and SLM performances as a measure to verify the effectiveness of the proposed scheme. To evaluate the PAPR and SLM performances of CCDF function schemes for PAPR reduction, a QPSK modulated OFDM system is taken into consideration.

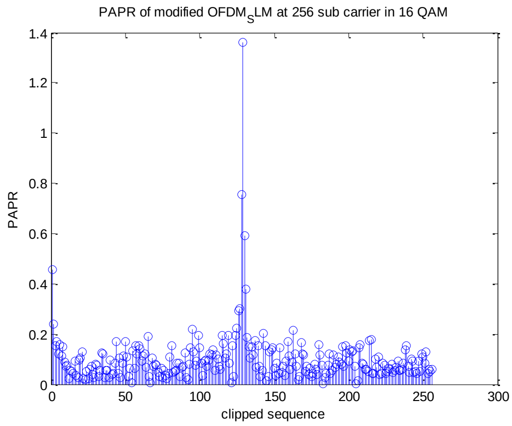

Figure 6: PAPR of modified OFDM SLM technique at 256 sub carrier in 16 QAM

As per the above figure we can see that, the performance of modified OFDM SLM technique is better than the normal OFDM SLM technique on 256 sub-carrier.

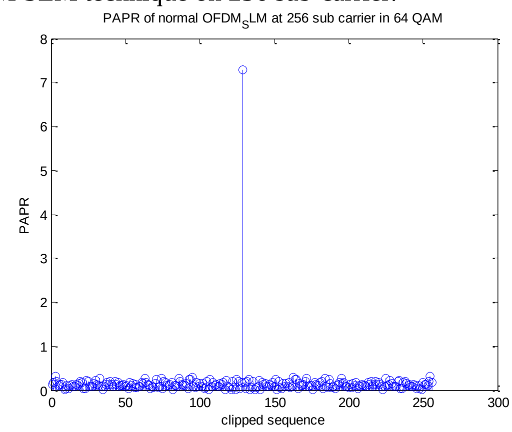

Figure 7: PAPR of normal OFDM SLM technique at 256 sub carrier in 64 QAM

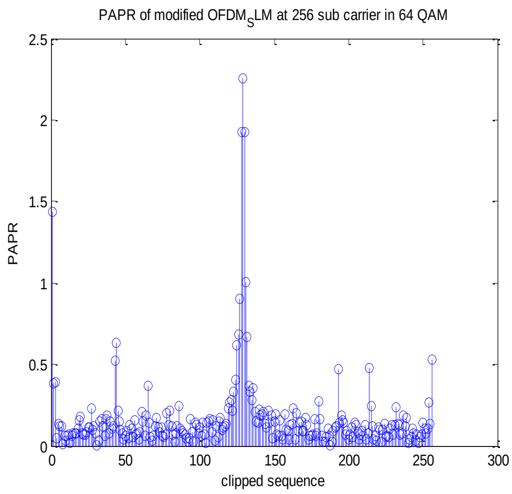

Figure 8: PAPR of modified OFDM SLM technique at 256 sub carrier in 64 QAM

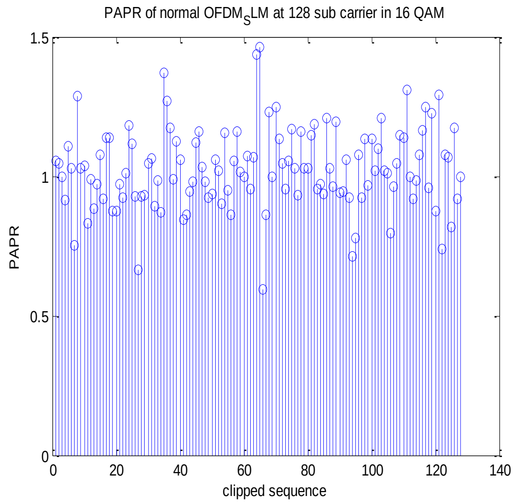

Figure 9: PAPR of normal OFDM SLM technique at 128 sub carrier in 16 QAM

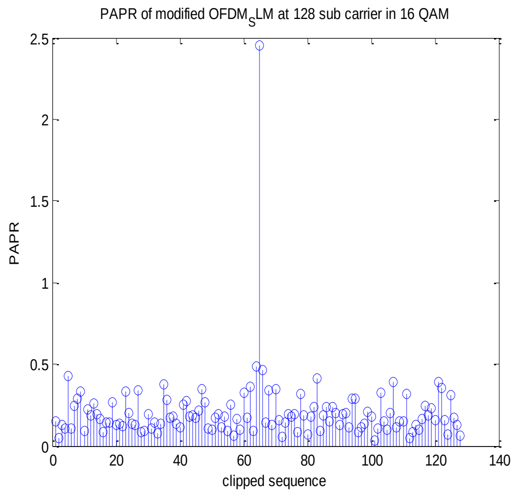

Figure 10: PAPR of modified OFDM SLM technique at 128 sub carrier in 16 QAM

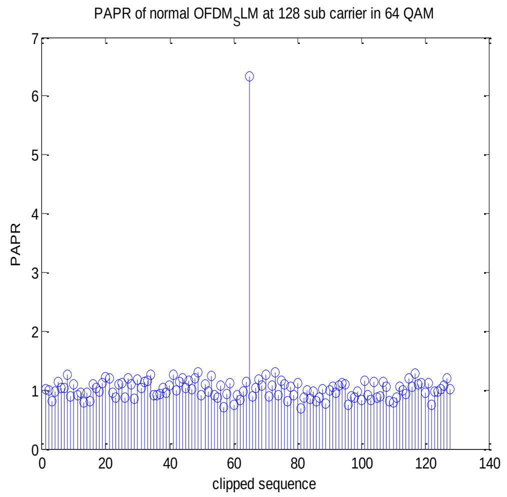

Figure 11: PAPR of normal OFDM SLM technique at 128 sub carrier in 64 QAM

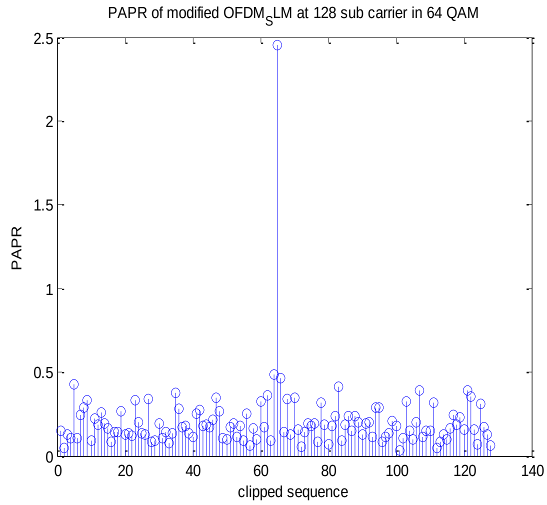

Figure 12: PAPR of modified OFDM SLM technique at 128 sub carrier in 64 QAM

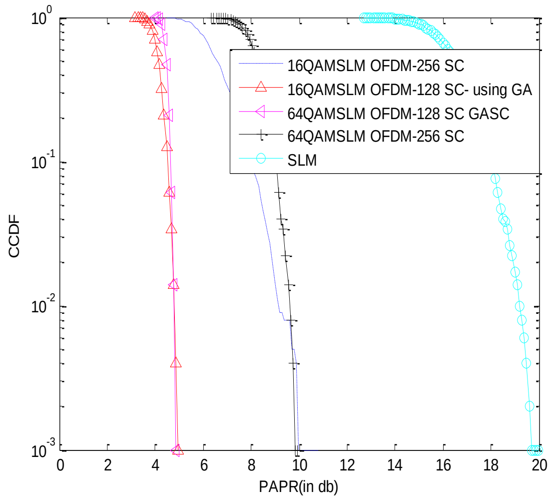

Figure 13: A comparison of different modulation subcarriers in CCDF

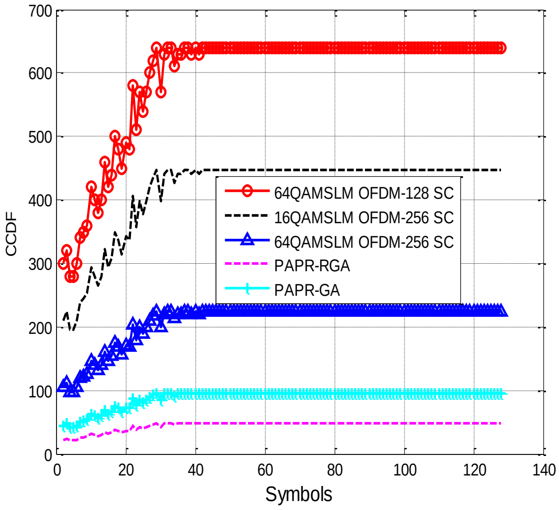

Figure 13: A comparison of different modulation subcarriers in CCDF on 50 symbols

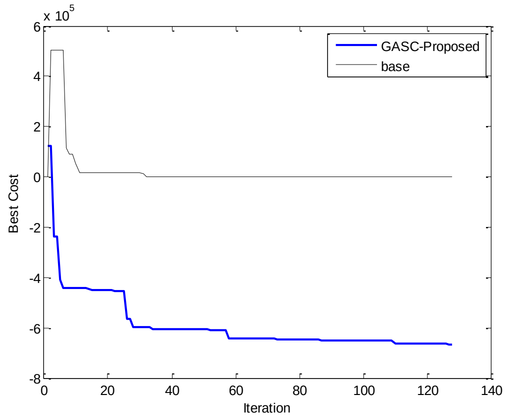

Figure 14: A graph of Best cost on iteration

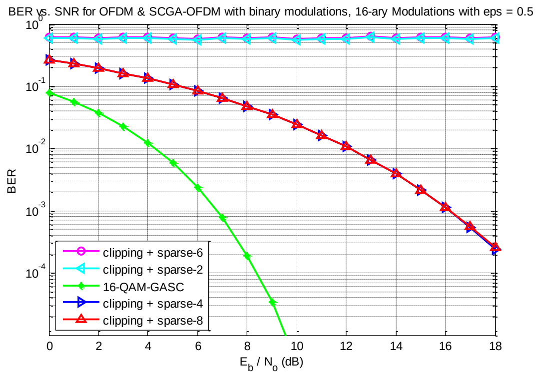

Figure 15: BER vs. SNR for OFDM & SCGA-OFDM with binary modulation, 16-ary modulation with eps=0.5

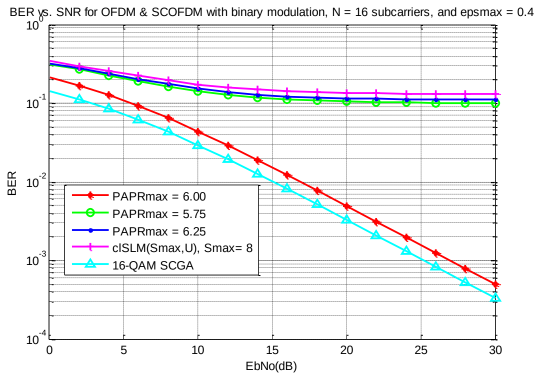

Figure 16: BER vs. SNR for OFDM & SCOFDM with binary modulation, N=16 subcarriers, and epsmax=0.4

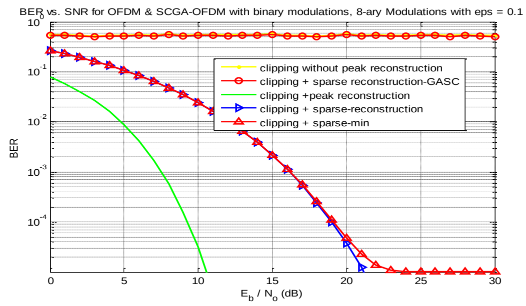

Figure 17: BER vs. SNR for OFDM & SCGA-OFDM with binary modulation, 8-ary modulation with eps=0.1

Aiming at these problems, we proposed a method of QAM-OFDM channel estimation combining orthogonal genetic optimization. It can retain the orthogonally of different sub-carriers of OFDM which are produced by different transmit-receive channel estimation couples or transmit-receive.
The proposed scheme firstly relies on a pseudo random preamble which is identical for all regular antennas to acquire the partial common support and inverse transmission scheme by using Genetic search assistances fast convergence and can handle large allocations of subcarriers to users without presentation deprivation theorem which using the sparse common support property of the PAPR. And then a very small amount of frequency domain orthogonal pilots are used for the accurate channel recovery. The proposed scheme is to evaluate CCDF using Genetic Multiple Input OFDM (GM-OFDM) technique that provides better performance and higher spectral efficiency than the conventional PAPR-OFDM schemes.

VI. CONCLUSION

OFDM is a encouraging technology in wireless communication. And high PAPR is the most perplexing issue in OFDM systems. Selected Mapping is an well-organized method to limit high PAPR. In this work we have proposed SLM-GA with Segmentation and SLM with Interleaving. And the techniques give rise in further fall in PAPR than the conventional Selected Mapping. Among the proposed techniques SLM-GA with Interleaving has greater PAPR reduction performance.

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