

## PAPR Reduction Using PSO-GSA Tuned PTS Techniques in MC-CDMA System

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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. This dissertation mainly focusses on implementation of PTS technique to MC-CDMA scheme for downlink scenario. Also, a low complexity receiver is designed for the above scheme where the equalization is carried out in time domain basis. Also the proposed MC-CDMA with PTS scheme is compared with Single Input Single Output (SISO) MC-CDMA with PTS scheme in terms of Complementary Cumulative Distribution Function (CCDF) and Bit Error Rate (BER) performance. The simulation results verify that proposed MC-CDMA outperforms SISO MC-CDMA under fading conditions. Also as the no of users increase, CCDF performance improves and BER performance degrades.

**Index Terms**— Multi Carrier Code Division Multiple Access, PTS, OFDM, SISO.

### I. INTRODUCTION

Single carrier systems suffer from heavy Inter Symbol Interference (ISI). ISI occurs when the signal bandwidth is less than the coherence bandwidth or equivalently when the delay spread is greater than the symbol duration. To combat the problem of ISI multicarrier techniques have been proposed. Multicarrier techniques divide the whole bandwidth

into large no of narrow band orthogonal subcarriers [1, 2]. Thus the signal bandwidth becomes very less compared to the coherence bandwidth ensuring no ISI in time domain and flat fading in frequency domain. Multicarrier systems such as Orthogonal Frequency Division Multiplexing (OFDM) and Multi Carrier Code Division Multiple Access (MC-CDMA) are considered to be the promising technologies for 4G wireless communication systems [1, 2]. Fig. 1.1 explains the spectrum of multicarrier and single carrier systems. In single carriersystem the information symbols are loaded onto one subcarrier whereas in multicarrier system the information symbols are loaded onto multiple no of subcarriers. Recently, Code Division Multiple Access (CDMA) which is the basis of all 3G wireless communication system is a spread spectrum technique and has gained a lot of attention to support multimedia services in mobile radio communication. On the other hand, OFDM which is a multicarrier technique is considered to be the basis of all 4G wireless communication systems.

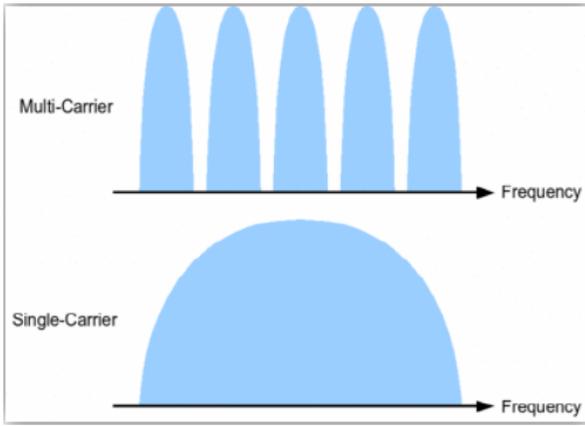


Fig. 1.1 Conventional spectrum of multicarrier and single carrier systems [19]

CDMA spreads the data symbol in frequency direction. The same chip will be transmitted on different subcarriers thus increasing the frequency diversity. MC-CDMA preferred to be used in downlink. Since downlink is synchronous we don't have to pay attention to the autocorrelation properties of the spreading code. Simple Walsh-Hadamard (W-H) code can be used for spreading which has very good orthogonality property. MC-DS-CDMA spreads the data symbol in time direction after spreading thus increasing the time diversity. MC-DS-CDMA is used in uplink scenario. In uplink Pseudo Noise (PN) code is used since uplink transmission is asynchronous. Since MC-CDMA is a combination of CDMA and OFDM it takes advantage of both the schemes and inevitably has the same drawbacks [2]. MC-CDMA spreads the data with a particular spreading code in frequency direction thus increasing frequency diversity whereas MC-DS-CDMA spreads the data in time direction and MT-CDMA uses very high spreading factor [3]. This dissertation mainly focuses on signal processing aspects of downlink multiuser MC-CDMA. Since the downlink (from Base Transceiver Station (BTS) to Mobile Station (MS)) is considered to be synchronous, orthogonal codes can be used for spreading since they reduce multiple access interference. Walsh-Hadamard (W-H) code [2] is used for spreading since they are easy to generate and they have very good orthogonality property.

## II. PROPOSED WORK

In our work as PAPR of OFDM has to be reduced. There are various methods available for this purpose, but from the literature review it has been clear that partial transmit sequence (PTS) is the most effective method. But in PTS too length of sub blocks considered and the weighted factor sequence data can change the reduction in PAPR and can show improvement. In our work focus is to set the weighted sequence such that PAPR settle to a minimum value. Bioinspired optimization algorithms helped in this. There are various algorithms available but every algorithm if used alone suffers from some drawbacks and majority of them are suffered from premature convergence i.e. in case of

multiobjective optimisations they skipped many points of iterations and can't look for a minimum solution & fall into a local minima. The problems faced during OFDM are :

- (i) The major negative aspect with OFDM is high Peak-to-
- (ii) Average Power Ratio (PAPR). Due to high PAPR results in nonlinear distortion at a high power amplifier (HPA) and degradation of the bit error rate (BER). To handle these occasional large peaks, a high-power amplifier with linear characteristics is required.

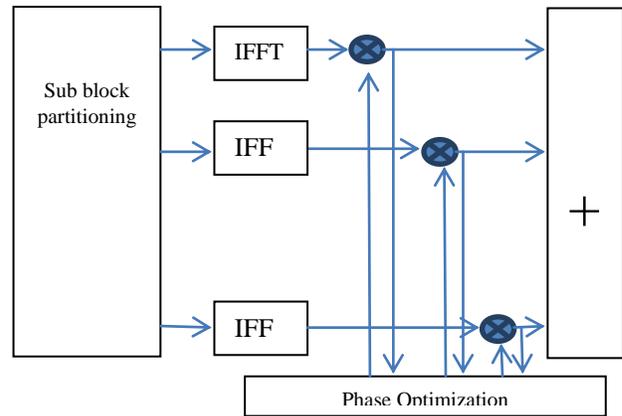


Figure 2.1: Block diagram of conventional PTS

(ii) There are various methods for reducing PSNR like selective mapping (SLM), partial transmit sequence (PTS) etc. mainly PTS is used for this purpose even it is a special case of SLM because of less complexity in PTS.

(iii) In PTS optimization of weighting factor is done so that PAPR is reduced. For optimization different techniques like ACO, PSO, etc. but these suffers for premature convergence of result.

### Proposed Methodology

In this partial transmit sequence method is used which is discussed here. This method is based on phase shifting of sub-blocks of data and multiplication of data structure by random vectors. The main purpose behind this method is that the input data frame is divided into non-overlapping sub-blocks and each sub-block is phase shifted by constant factor to reduce PAPR. In the PTS technique, an input data block of  $N$  symbols is partitioned into disjoint sub-blocks. The subcarriers in each sub-block are weighted by phase factor for that sub-block. The main purpose behind this method is that the input data frame is divided into non-overlapping sub-blocks and each sub blocks.

1. Set all the phase factors  $b_v$  for  $v=1:V$ , find PAPR of equation (3), and set it as  $PAPR_{min}$ .
2. Set the  $v=2$ .
3. Find PAPR of equation (3) with  $b_v = -1$ .

4. If  $PAPR > PAPR_{min}$ , switch  $b$  v back to 1. Otherwise, update  $PAPR_{min} = PAPR$ .
5. If  $v < V$ , increment  $v$  by 1 and go to step 4.

We consider the PAPR as our objective function an specifically peak power only as PAPR is the ratio of peak to average power, so if peak power is reduced then automatically PAPR also reduces. Initially PSOGSA is executed as the main optimization technique. The agent's initial positions are randomly chosen and these make the weighted factor of PTS. Steps of proposed algorithms are described as:

- Step1.** Initialize all initial parameters of OFDM to model it.
- Step2.** Generate the input bits and modulate them as per the modulation instructed by user
- Step3.** Generate hadamard sequence or Walsh code and spread the modulated input with this code to provide the uniqueness to each user's data.
- Step4.** Take the sum of these spreader sequences and partitioned it into sub blocks for PTS.
- Step5.** Take the inverse Fourier transform of these partitioned blocks and pass to proposed optimization being used.

#### PSOGSA Initialization

- Step1.** Initialize the random positions of particles in PSO.
- Step2.** Consider the searching space dimension as number of total binary digits for bandwidth, energy and memory
- Step3.** Initialize the weighting parameters of PSO as 0.2 and 0.5.
- Step4.** Compare the fitness value of each particle with the previous best position of bacteria. If fitness function value is less for this new position than previous position then it will be assigned as new.
- Step5.** The present best position is termed as current position of particle for PSO and output of fitness function is Local for the PSO.

*GSA Starts here:*

- Step6.** The current position selected in previous step is used to get the mass for each agent as per GSA algorithm. The minimum value of fitness function is selected as best and maximum as worst position and using the formulas, mass of each agent can be calculated as:

$$m_i(t) = \frac{fit(t) - worst(t)}{best(t) - worst(t)}$$

$$M_i(t) = \frac{m_i(t)}{\sum_{j=1}^N m_j(t)}$$

Gravitational force is calculated as:

$$F_{ij}^d(t) = G(t) \cdot \left( M_{pi}(t) \times \frac{M_{ai}(t)}{R_{ij}(t)} + \varepsilon \right) \cdot (x_j^d(t) - x_i^d(t))$$

The formula is described in section 3.1.

- Step7.** This new velocity is the direction of particle in PSO is updated as  
*new velocity*

$$= old\ velocity + c1 * acceleration + c2(gbest - current\ position)$$

Here gbest is the global best position of particles in PSO and acceleration is calculated in GSA as

$$a_i^d(t) = F_i^d(t) / M_{ii}(t).$$

*GSA ends here*

- Step8.** The final position of agents which is achieved either by matching the condition of power reduction or by reaching the maximum iterations.

- Step9.** Final positions of agents thus settled are considered as the final weighted sequence of PTS algorithm and multiplied with input sub blocks and PAPR is calculated.

### III. RESULTS

In our work we have proposed a hybrid evolutionary optimisation algorithm which is combination of PSO and GSA as discussed in previous chapter. PSOGSA optimisation as described earlier to optimise the combination of PTS for minimisation of PAPR in MC-CDMA. The proposed work is implemented in MATLAB R 2013a. A lot of inbuilt functions in MATLAB makes the use easier and saves our time to build our code from scratch. So we can use that time in problem solution of research.

During the PSOGSA implementations we have to provide the input of number of agents, total number of iterations and range to the PSOGSA.m script. This gives the better results in PSOGSA. Some test functions are used hybrid algorithm with both the standard PSO and GSA algorithms. The values of these inputs are tabulated in table 3.1.

Table 3.1: input variables set in GSA optimization

Input	Value
Total number of agents	10
Total iterations	50

Range	[-1,1]
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We have developed MC-CDMA communication system in MATLAB. So simulation parameters considered for this implementation are given in table 3.2.

Table 3.2: Simulation parameters of MC CDMA

Spreading codes of MC CDMA	Walsh code
Modulation process	QPSK,8PSK, 16PSK
Number of users in MCCDMA	4,8,10,12
Number of subcarriers	16,32,64
Length of sub blocks of PTS	4,6,8
No of bits for each user	10000

We have divided our work in four sub cases which are

Keeping the other factors constant at some value, only number of users are changed

1. Type of modulation varies
2. Subcarriers in MC-CDMA also affects the PAPR so it's variation is also considered.
3. The size subblocks of PTS is also varied

*Case I: no of users changes*

Initially 4 users have been taken along with QPSK modulation, number of subcarriers=8 and length of subblocks of PTS is 4. Figure 3.3 shows the constellation map of modulated input of MC-CDMA by QPSK and scatter diagram of QPSK is shown in figure 3.4.

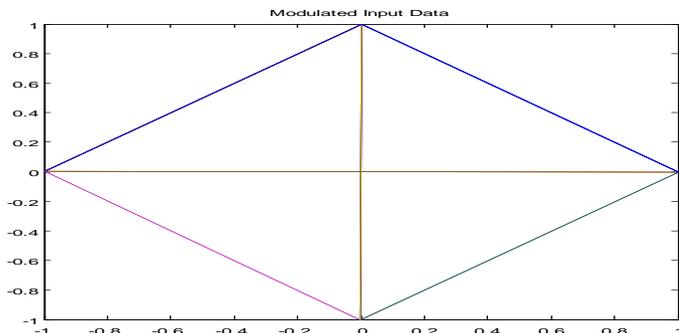


Figure 3.3: Constellation Map of 4-PSK Modulated Data

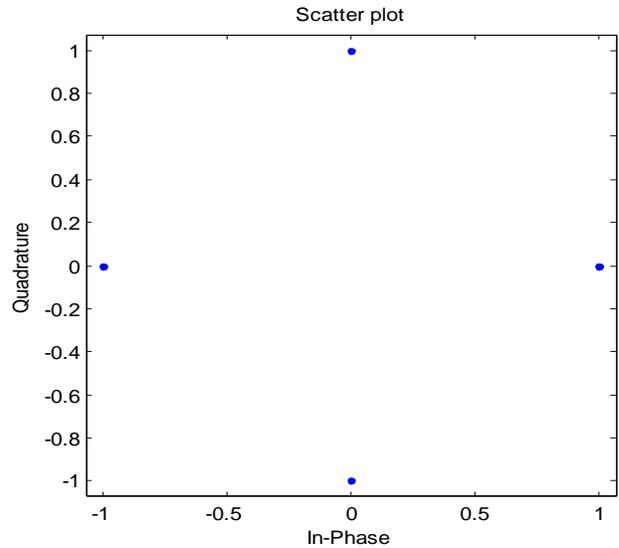


Figure 3.4: Scatter plot of QPSK modulation

The comparison plot for both optimization techniques in case of every unique no of users is shown in figure 3.5 for different number of sub blocks too.

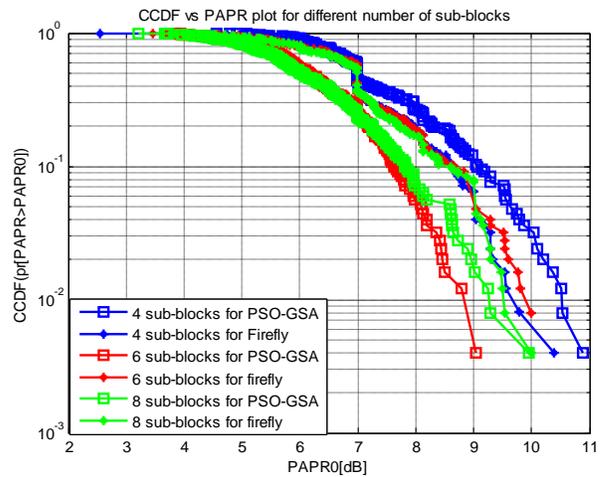


Figure 3.5: PAPR vs. CCDF for different 8 numbers of Users with different sub blocks length

As is seen from the figure with the increase in the number of users the PAPR is also increased, but if it is compared in case of each different number of users then PAPR reduces significantly by our proposed algorithm. Table 3.6 clearly proves our point.

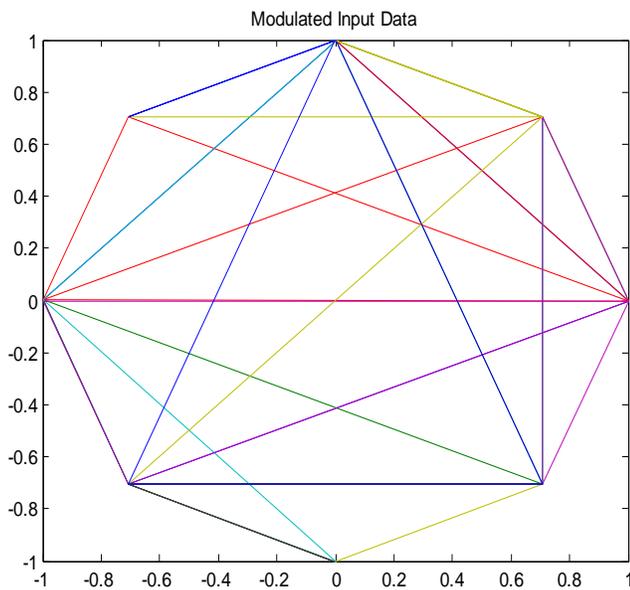
Table 3.6: PAPR for proposed work and firefly-PTS for different number of users for 4 sub blocks

No of Users	PAPR of Firefly-PTS(dB)	PAPR of PSO-GSA-PTS(dB)
4	10.1740	9.7636
8	8.8413	9.0862
10	9.9402	9.6023

This table clears the point that our proposed algorithm improves the PAPR than firefly tuned PTS scheme.

*Case II: when modulation is changed*

In this case modulation type of MC- CDMA is changed which also changes the modulated input, number of users is kept fixed to 8 users, subcarriers are set to 8 and sub block length of PTS is 4.



(a): 8PSK scattering of modulated input

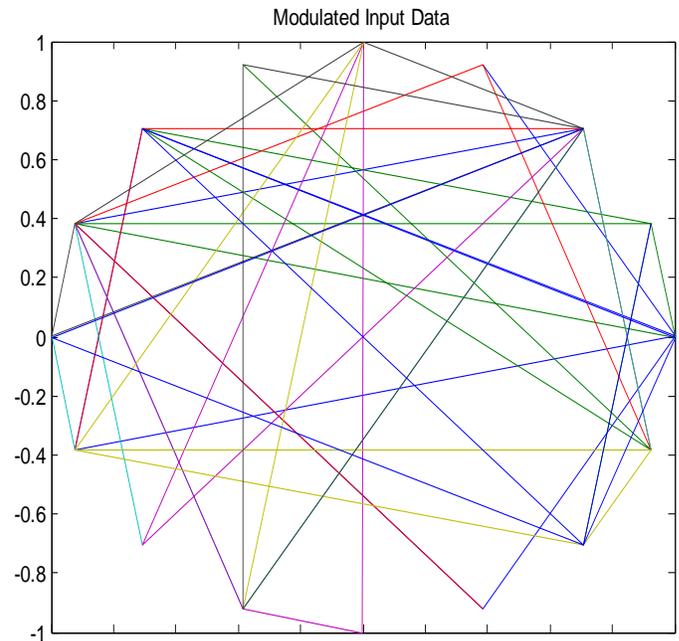


Figure 3.7: Scatter pattern of 16PSK modulated input data

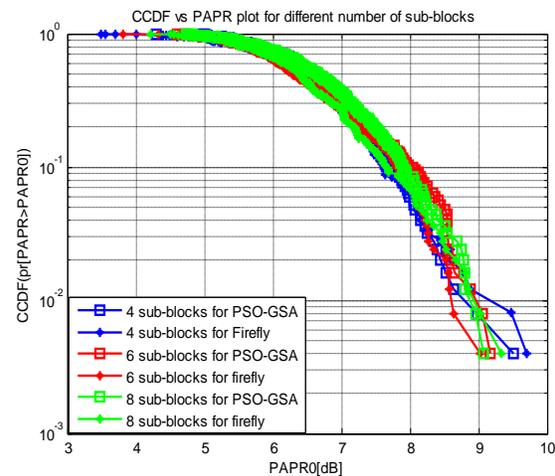


Figure 3.8: PAPR vs. CCDF curve for 8PSK modulation schemes for different number of sub blocks

Below table 3.9 shows the final PAPR value for different modulation scheme which will provide a crisp comparison of PAPR improvement to firefly algorithm.

Table 3.9: PAPR for proposed work and firefly-PTS for different modulation schemes for 4 sub blocks

Modulation scheme	PAPR of Firefly-PTS(dB)	PAPR of PSOGSA-PTS(dB)
4	9.0341	9.6954
8	8.6511	10.0274

16	9.0801	10.4332
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*Case III: Number of sub carriers is varied*

In 3<sup>rd</sup> case subcarriers of MC-CDMA are varied. These are basically the number of channels which are required for parallel transmission of data. In this case 8 users are considered along with QPSK modulation scheme and length of PTS sub blocks is taken 4. The comparison graph for different sub-blocks is shown in figure 3.10.

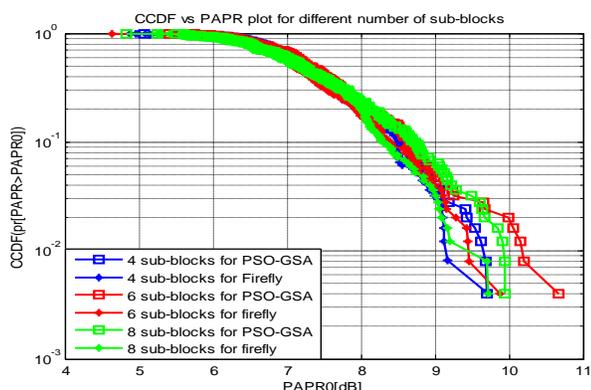


Figure 3.10: PAPR vs. CCDF for different number of subcarriers.

In this case, with the increase in number of subcarriers keeping all other factors constant, PAPR increases with number of sub carriers.

Table 3.11: PAPR for proposed work and firefly-PTS for different sub carriers for 4 sub blocks

	PAPR of Firefly-PTS (dB)	PAPR of PSOGSA-PTS (dB)
8	9.9460	9.6505
16	10.5861	10.1535
32	10.4223	9.8511
64	11.0418	10.6459

*Case 4: Length of PTS blocks are varied*

In this case only length of sub blocks in PTS is changes and other conditions are same as previous discussed cases. The comparison curve for this case is shown in figure 3.12 below. The table and graph shows that our proposed scheme for PAPR improvement works well when length of sub-blocks of PTS increases. If length of sub block is taken 8 then improvement in PAPR is approx. 2 dBs Best improvement in CCDF is also visible in this case as slop of curve is less as compared to other cases.

Table 3.13: PAPR values for different subcarriers

Number of PTS sub-blocks	PAPR of Firefly-PTS (dB)	PAPR of PSOGSA-PTS (dB)
4	12.1843	12.1843
6	11.2280	10.4671
8	11.8327	10.4878

Now at this stage where all possible cases are discussed, a collective representation of PAPR is required to get the parameters which gives best PAPR reduction. For this purpose a bar graph for all cases is itself which is shown in figure 5.10. This bar graph is only for PAPR using proposed method as PAPR always improved than PTS. From this figure it is concluded that at highest number of sub blocks of PTS the PAPR reduction is highest.

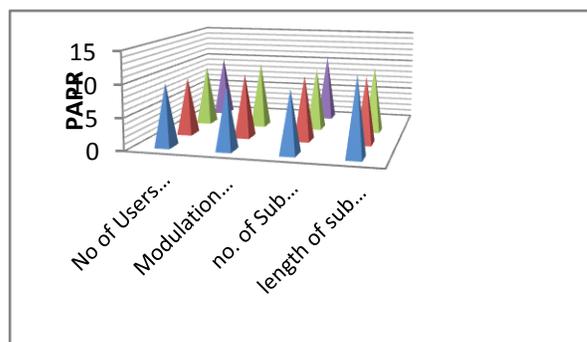


Figure 3.14: Bar graph for proposed scheme PAPR

**IV. CONCLUSION**

MC-CDMA has been the promising technology for 4G wireless communication system. Since it is a combination of both OFDM and CDMA, it explores the advantages of both the schemes. MIMO integrated with multicarrier techniques can boost the data rate and the reliability of the link. Also by using multi antenna elements MIMO can achieve diversity which in turn will improve BER performance thus improving the reliability at the receiver. So hadamard coded MC-CDMA is a suitable candidate in this regard which can achieve speed, range and reliability simultaneously. But the problem with multicarrier technique is PAPR which is also the major drawback for MC-CDMA and restricts its application. High PAPR causes inter modulation products, increases the cost of the transmitter, and increases the complexity of the ADC. So PAPR must be reduced at any cost. In this dissertation we have assumed that the receiver has the knowledge about channel coefficients. This may not be possible in adverse situations. So receiver side channel estimation is essential for better reception of the signal. Also we have assumed that the side information bits are known at the receiver. This means that additional spectrum is used for transmission of these side information bits. This may lead to data loss if these bits are significant. So the future work will be to estimate the transmitted bits without using side information bits.

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