Performance Estimation Of PTS Based PAPR Reduction With CFO Optimization Of Multi Carrier CDMA System Over Frequency Selective Fading Channel

T. Dineshkumar, Dr. P. Venkatesan

Abstract- Multicarrier Code Division Multiple Access is the most promising technique for high speed data transmission. However, the MC-CDMA signals are characterized by large peak to average power ratios (PAPR), which can reduce the system spectral efficiency. In this paper PAPR reduction of an MC-CDMA system using PTS technique is investigated by using whale optimization algorithm that uses pseudo random sequence for QPSK modulation techniques with different number of active users. Whale optimization algorithm optimizes the time delay and carrier frequency offset and thus minimizing the Inter Carrier Interference (ICI) from the carrier signal occurs. The results show that 64 bit QPSK shows better performance in case of Bit Error Rate, PAPR, spectral efficiency, and Carrier Frequency Offset for achieving high speed data transmission in MC-CDMA with PTS system.These all the results are taken for different modulation and the different channels.

Index Terms- MC-CDMA, QPSK modulation, Whale optimization, Frequency Selective fading, Partial Transmission Signal.

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1 INTRODUCTION

CODE-DIVISION multiple-access (CDMA) system has been considered to be a candidate to support multimedia services in mobile communications because it has its own capabilities to cope with asynchronous nature of multimedia data traffic, to provide higher capacity over conventional access schemes such as time-division multiple-access (TDMA) and frequency-division multiple-access (FDMA), and to combat hostile channel frequency selectivity [1]. Direct-sequence (DS) and frequency-hopping (FH) CDMA are the two types of CDMA [2]. One of the most important motivations behind the use of CDMA is to increase the number of simultaneous users in dense environments with acceptable error performance. Furthermore, MC DSSS RITs such as coded-domain NOMA [3] have already been recognized as potential candidates for future 5G networks due to their improved spectrum efficiency and robustness against more adverse conditions of channel frequency selectivity, more so when implemented in MIMO structures. Therefore, it has the potential to be adopted in future 5G high-density wireless networks. The direct sequence code division multiple access (DSCDMA) is a communication system that can support multiple users to transmit data within the same spectral band using their unique user-specific spreading codes [4]. At the receiver, the multiple user's signals are distinguished from each other using the same codes. Thus, DS-CDMA can provide high spectral efficiency. At the same time, since it spreads spectrum, it may lead to frequency selective fading in the channel. So, the orthogonal frequency division multiplexing (OFDM), which is a broadband multicarrier modulation scheme that offers resistance from intersymbol interference (ISI) by splitting a serial data into numerous orthogonal narrowband streams, can be integrated to DS-CDMA to make frequency fading channel into flat fading channel. The resultant technique can be formally called as MC-CDMA system [5]. To cope with frequency selective fading and ISI, MCSS is a wise choice with provision of high data rate. MC-CDMA, MT-CDMA and MC-DS-CDMA are the three types of MCSS [6]. MC-CDMA uses the concept of spreading as in CDMA and orthogonal subcarriers as in OFDM. Each symbol is spread using a unique code and modulated on a separate subcarrier. Hence, symbol is spread in frequency instead of time. MC DS-CDMA and MT-CDMA are two different flavors of MC-CDMA, with their own advantages [7]. Though there are multiple benefits of these technologies yet they are sensitive towards synchronization errors and CFO (Carrier Frequency Offset) [8]. CFO is the fraction of difference in the frequencies of local oscillator between transmitter and receiver. It can be generated either by Doppler shift or by multipath fading. Different techniques to estimate CFO like training based method [9] and blind method [10, 11]. Most existing carrier estimation techniques in OFDM rely on periodic transmission of reference symbols, which inevitably slightly reduces the bandwidth efficiency. A subspace-based blind approach was proposed for the interleaved OFDMA [12], which exploits the time-domain cyclo-stationarity of the signal structure [13]. To reduce the problem of estimating CFO for uplink multicarrier OFDM, a novel sparse blind CFO estimator is designed [14]. In particular, for single- or multi-carrier CDMA-type receivers, timing recovery is an essential operation for CDMA receivers. It is involved in channel coding, power control and more so in signal combining, making its impact crucial on capacity and throughput performance. The expectation maximization (EM) algorithm is used to find the global maximum of the likelihood function and hence the maximum likelihood estimate of the delays. However, under the effects of path loss, Rayleigh fading and shadowing, the channel coefficients become stochastic and, hence, there is a need of the channel covariance matrix in the expression of the likelihood function [16]. The performance of MC-CDMA system can be assessed by careful observation of the BER performance of the system considering various parameters such as modulation technique used, spreading code and its length, propagation and noise channels and the number of users.

2 RELATED WORKS

Si-Yue Sun et al. [17] proposed a joint pre-equalization and adaptive combining scheme. Pre-equalization is used at a transmitter to either enhance diversity gain or compensate channel selectivity leveraged by a controlling parameter, whereas a recursive least square (RLS) adaptive combining algorithm is employed at a receiver to determine the optimal combining coefficients, aiming at minimizing detection errors under different channel conditions. Simulation results demonstrated the superiority of the proposed scheme in terms of bit error rate (BER) and its adaptability to varying channel states. Yung-Fa Huang et al. [18] investigated the performance of a modified evolutionary multi-user detector (MUD) in multicarrier direct-sequence code-division multiple-access (MCCDMA) communication systems over frequency-selective fading channels. The genetic algorithm (GA), which tries to reduce the complexity in optimal detection due to greedy exhausted searching, performs using the adequate suboptimal multi-user detector for MC-CDMA systems. A forcing mutation scheme was proposed for the genetic algorithm (GA) to perform a forcing mutation evolutionary multi-user detector (FME-MUD) and to largely reduce computational complexity. Simulation results showed that with six generations, the FME-MUD scheme outperforms the conventional GA-MUD, especially at heavy system loads. The time delay evaluation (TDE) issues related to the single or multiple carrier Direct-Sequence Spread Spectrum (DSSS) multipath communication within the sight of various transmitting and receiving antennas which would describe the future 5G radio interface technologies (RITs) like coded-domain non orthogonal multiple access (NOMA) were addressed by Ahmed et al. [19].

Motivation & Problem statement

Minimum delay and channel behavior computing is major thing for high speed applications such that the system can keep away from inter carrier interference (ICI) among subsequent frequency components and inter symbol interference occurring among neighboring symbols. Multiuser wireless systems using multicarrier modulation suffer from the effects of dispersive fading channels, which create multi-access, inter-symbol, and inter-carrier interference. OFDM plays a pivotal role in wireless communications due to its high data rate handling ability and robustness to frequency selective fading channels. OFDM is a robust scheme to frequency selective fading, however, it has several disadvantages such as difficulty in subcarrier synchronization and sensitivity to frequency offset and nonlinear amplification, which result from the fact that it is composed of a number of subcarriers with their overlapping power spectra and exhibits a non-constant nature in its envelope. However, the combination of OFDM signaling and CDMA scheme has one major advantage that it can lower the symbol rate in each subcarrier so that a longer symbol duration makes it easier to quasi-synchronize the transmissions. Conventional channel estimation models such as least mean square and minimum mean square error lack performance while handling complex data.

3. PTS BASED PAPR REDUCTION WITH CFO OPTIMIZATION

System model

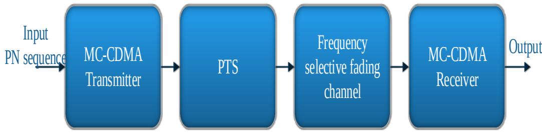

Figure1. System model for the proposed work

The notion of MC-CDMA system is to spread the i^{th} user data sequence $b_k^{(i)}$ $(1 \le i \le U$ where U is the maximum number of users) using the spreading code $C_k^i(0 \le k \le N - 1$ where N is the number of subcarriers). Walsh-Hadamard code, an orthogonal code used for spreading, provides minimum multiple access interference in the frequency selective fading channel. All the 'U' users CDMA signals are subsequently mapped into 'N' subcarriers using PTS technique. The composite CDMA signal of all the 'U' users, for the k^{th} chip of the spreading sequence, is expressed as

$$X(k)=\sum_{i=1}^{U} a_k^{(i)} C_k^{(i)} \qquad k=0,1,2,\dots,N-1 \quad (1)$$

Where, $a_k^{(i)}$ is the bipolar non-return to zero (BNRZ) representation of binary data sequence $b_k^{(i)}$. The data signal $a_k^{(i)}$ and spreading signal $C_k^{(i)}$ take the value of ± 1. The MC-CDMA signal, an inverse FFT (IFFT) of CDMA signal, is given by

$$X_n=\frac{1}{N}\sum_{k=0}^{N-1} x(k)\exp^{j2\pi nk/N} \quad (2)$$

Where, $k=0,1,\dots,N-1$. PAPR can be defined as the ratio of maximum instantaneous peak power to the average power of a PTS system. PAPR can be expressed in discrete form as follows:

$$PAPR(x(k))=\frac{\max\limits_{0\le k\le N-1}|x(k)|^2}{E\left[|x(k)|^2\right]} \quad (3)$$

Here, the expectation operator is represented as $E[.]$. The cyclic prefix 'cp' is inserted and the signal is transmitted through the frequency selective fading channel.

$$X_n=\frac{1}{N}\sum_{k=0}^{N-1} x(k+cp)\exp^{j2\pi nk/N} \quad (4)$$

After adding the noise, the MC-CDMA is

$$X_n=\frac{1}{N}\sum_{k=0}^{N-1} x((k+cp)+Fn)\exp^{(j2\pi n(k+cp)/N)} \quad (5)$$

In this above equation (5), Fn is the noise in the fading channel and that removes the cyclic prefix at the receiver with the following equation (6).

$$X_n=\frac{1}{N}\sum_{k=0}^{N-1} x((k1)+Fn)\exp^{(j2\pi k(3.14)/N)} \quad (6)$$

Finally taking Fast Fourier Transform (FFT) at the receiver side, then the equation is shown below:

$$x(k1)=\frac{1}{N}\sum_{k=0}^{N-1} X_n \exp^{-j2\pi kn} \quad (7)$$

In this research, estimation of the performance analysis of Multi-carrier modulation of CDMA with MIMO in frequency selective fading channel in modulation technique to adjust BER optimization is done. For that, considering the detection of Multi-Carrier-Code Division Multiple Access signals in frequency selective fading channels using partial channel equalization is necessary. This research work identifies the issues in existing models and proposes a cyclic prefix based estimation model for carrier frequency offset. In this research, based on the received carrier phase angle and cyclic prefix information the carrier frequency offset is estimated in combination with a novel evolutionary adaptive brain storm optimization algorithm for efficiency enhancement.

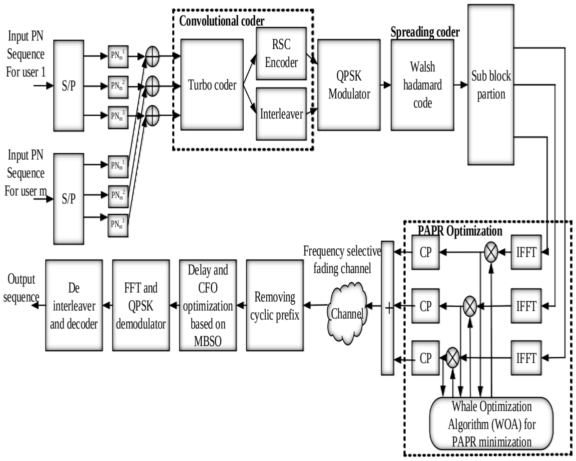

Figure 2. Schematic representation of the proposed MC-CDMA system

Figure 2 shows the schematic representation of the proposed methodology. Initially a Pseudo random Noise Sequence is generated which is a binary sequence and it can be generated through a circuit or an algorithm appears to be statistically random like in the case of a fair coin flipping. PN sequences are defined with the help of a polynomial of degree n:

$$PN(x)=\sum_{i=0}^{n} A_i x^i \quad (8)$$

With $A_i \in F_2$. The PN Sequence corresponding to this will satisfy the following recursion:

$$PN_{n+k}=\sum_{i=0}^{n-1} A_i PN_{k+i} \quad (9)$$

Over the field F2. Note that the $PN(x)=0$ in which characteristic equation of the mentioned recursion. Next to that the pseudo noise sequence is coded with turbo encoding technique which improves the frequency selective channel capacity.

PTS based PAPR reduction

After the QPSK modulation, In PTS, PAPR reduction is based on the sampled, discrete-time signal which can be written as

$$PN(x) = \sum_{i=0}^{n} A_i x^i \qquad (10)$$

Where L is the over sampling factor. The PAPR computed from the L-times over sampled OFDM signal can be defined as

$$PAPR(PN[x]) = \frac{\underset{0 \le n \le LN-1}{MAX} \left(\left| PN[x] \right|^2 \right)}{E \left| PN[x] \right|^2} \qquad (11)$$

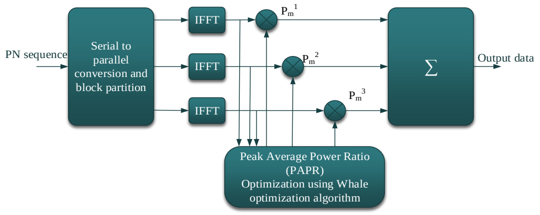

Figure 3. Diagrammatic representation of the PTS based PAPR reduction

The principle structure of PTS method is shown in Fig. 1. The input data block x is partitioned into m disjoint sub blocks $x_m, m = 1, 2 \ldots M$ .Here all the sub blocks are combined to minimize the PAPR in the time domain. *L*-times oversampled time domain signal of x_m is denoted as $X_m, m = 1, 2 \ldots M$, which are obtained by taking an IDFT of length nl on x_m concatenated with (l − 1)n zeros. Each x_m is multiplied by a phase weighting factor $P_m = e^{j\varphi_m}$ in the pseudo random noise sequence, where $\phi m \in [0, 2\pi)$ for $m = 1, 2 \ldots M$. The goal of the PTS approach is to find an optimal phase weighted combination to minimize the PAPR value. The transmitted signal in the time domain after combination can be expressed as

$$x'(P_m) = \sum_{i=1}^{m} P_i x_i \qquad (12)$$

Where $x'(P_m) = [x'_1(P_m), x'_2(P_m), \ldots, x'_{nl}(P_m)]$ (13)

In general, the selection of the phase factor is limited to a set with finite number of elements to reduce the search complexity. The set of allowed phase factors is

$$P_m = e^{j2\pi L/w} \mid L = 0,1,\ldots w-1 \qquad (14)$$

Where w is the number of allowed phase factors. A phase factor without any performance loss can be fixed. There are only $m-1$ free variables to be optimized and hence w^{m-1} different phase vectors are searched to find the global optimal phase factor. The search complexity increases exponentially with m , the number of sub-blocks.

Minimize PAPR using modified whale optimization algorithm

In order to get the OFDM signals with the minimum PAPR, a suboptimal combination method based on the whale optimization algorithm is proposed to solve the optimization problem of PTS. The modified ABC algorithm with lower complexity can get better PAPR performance. The minimum PAPR for PTS method is relative to the problem. To minimize phase weighted component of PN sequence in order to reduce PAPR value.

$$f(P_m) = \frac{\max \left| x'(P_m) \right|^2}{E \left| x'(P_m) \right|^2} \qquad (15)$$

Here $P_m \in \left\{ e^{j\varphi_m} \right\}^m$ (16)

Where $\varphi_m \in \left\{ \frac{2\pi k}{w} \mid k = 0,1,.. w-1 \right\}$ (17)

In this paper, selection of the phase factor (P_m) is = {−1, 1} or P_m = {−1, 1, *j*, −*j*}.

In this whale optimization algorithm, food sources are initialized as $p_m = [p_{m1}, p_{m2}, \ldots p_{im}]^T$ i=1,2 …S, where *S* denotes the size of a randomly distributed initial population. The nectar amount of a food source or fitness value of a solution b*i* in the population is determined by the following formula:

$$fitness(P_m) = \frac{1}{1 + f(P_m)} \qquad (18)$$

$$Objective_1 = \min(fitness(P_m)) \qquad (19)$$

4 EXPERIMENTAL RESULTS AND DISCUSSION

The proposed work is implemented in the MATLAB 2016 simulation tool. In which PAPR, carrier offset and the time delay is reduced with the whale optimization algorithm. The chosen wireless network metrics are defined and validated at this instant. The chosen values for frequency is 24 GHz and 86 GHz. Even though numbers of values are simulated at the start, the results from the two values mentioned above are simply recorded in the majority cases so as to avoid an overwhelming capacity of an unnecessary data at the time of conversation. The values of the fading margin are in the range of 28 dB to 35 dB. It is assumed that the receiver has perfect knowledge about the signal-to-noise ratio (SNR) and the noise variance. The encoder used is a turbo encoder with code rate = 1/n and constraint length K, which is combination of two recursive systematic convolution (RSC) coders which are joined by an interleaver and a feedback.

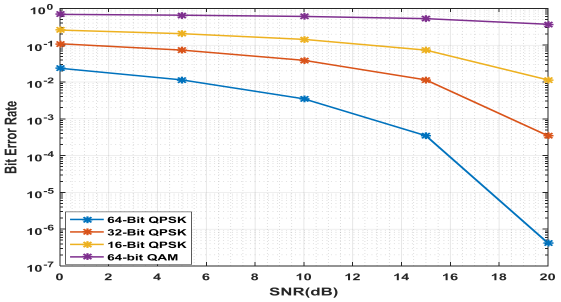

Figure 4. BER vs SNR performance

In this above figure 4, Bit Error Rate (BER) performance is evaluated in terms of Signal to Noise Ratio (SNR). From the figure, it shows that, while increasing an amount of SNR, the BER is reduced. Here the evaluations are taken for different modulations namely QPSK and QAM. The proposed work has been implemented for the 64 bit QPSK, so this will be compared with the existing modulation schemes namely 32 bit QPSK, 16 bit QPSK and 64 QAM respectively. In this 64bit QPSK, the value of BER has been fall into 0.5×10^{-5} which produces high performance while compared to all other modulation schemes. While comparing to all the modulation schemes 64 QAM yields lesser performance which is 60% less than the proposed work. So the BER should be low in order to yield the high speed transmission in the 5G communication system.

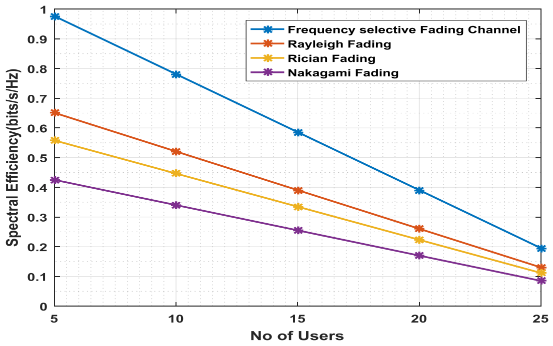

Figure 5. Spectral efficiency performance

In this figure (5), spectral efficiency is calculated in terms of number of users showing that, while increasing the number of users, the spectral efficiency has been reduced. Here the evaluations are taken for different modulations namely QPSK and QAM. The proposed work has been implemented in the frequency selective fading channel, so this will be compared with the existing modulation schemes namely Rician fading channel, Rayleigh fading channel and Nakagami fading channel respectively. In this frequency selective fading channel, the value of spectral efficiency has been reached into the 0.98 bits/sec/Hz which produces high performance while compared to all other channel schemes. While comparing to various channels Nakagami yields lesser performance which is 12% less than the proposed work. So the spectral efficiency should be high in order to yield the high speed transmission in the 5G communication system. In the figure 6, CFO performance is evaluated in terms of Signal to Noise Ratio (SNR). From the figure, it can deliberated that, while increasing an amount of SNR, the CFO is increased. Here the evaluations are taken for different modulations namely QPSK and QAM. The proposed work has been implemented for the 64 bit QPSK, so this will be compared with the existing modulation schemes namely 32 bit QPSK, 16 bit QPSK and 64 QAM respectively. In this 64bit QPSK, the value of CFO has been reached into 0.6×10-6 which produces high performance while compared to all other modulation schemes. While comparing to all the modulation schemes 64 QAM yields lesser performance which is 14% less than the proposed work. So the CFO should be low in order to yield the high speed transmission in the 5G communication system. Table 2 shows the CFO estimation for 64-QPSK, 32-QPSK, 16-QPSK and64-QAM modulation schemes.

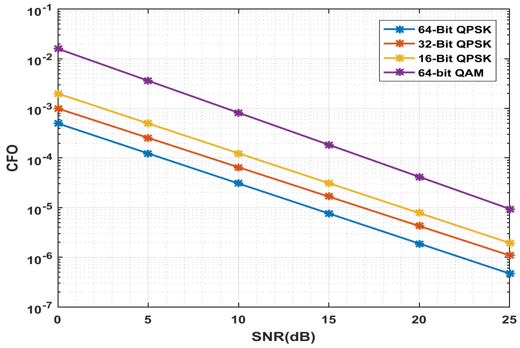

Figure 6. Carrier Frequency Offset (CFO) performance

Table2. Carrier Frequency Offset estimation (CFO) for 64-QPSK, 32-QPSK, 16-QPSK and64-QAM modulation schemes

Modulation Scheme / SNR	0dB	5dB	10dB	15dB	20dB	25dB
64 -QAM	0.016	0.003	0.0007	0.0002	3.22×10^{-5}	6.84×10^{-6}
16-QPSK	0.002	0.0006	0.0002	4.33×10^{-5}	1.21×10^{-5}	3.38×10^{-6}
32- QPSK	0.001	0.0003	6.66×10^{-5}	1.72×10^{-5}	4.45×10^{-6}	1.15×10^{-6}
64-QPSK	0.0004	0.0001	3.13×10^{-5}	7.85×10^{-6}	1.97×10^{-6}	4.94×10^{-7}

Table3. Spectral Efficiency (%) of proposed system for different fading channels

Type of fading / No. of Users	5	10	15	20	25
Nakagami Fading	0.425	0.340	0.255	0.170	0.085
Rician fading	0.558	0.446	0.335	0.223	0.111
Rayleigh Fading	0.651	0.521	0.391	0.260	0.130
Frequency Selective Fading	0.977	0.781	0.586	0.391	0.195

In the above table 3, the values for the various modulations in terms of BER, NMSE, MMSE, MLSE, MSE, PAPR and CFO are measured. In addition to that the spectral efficiency is measured for the number of channels. Here various channels namely frequency selective channel for the proposed work, Rayleigh fading channel, Rician fading channel and Nakagami fading channels are evaluated. Compared to all the techniques our proposed work achieves minimum PAPR and high spectral efficiency and it since it is can be used for high efficient and reliable high speed transmission.

6 CONCLUSION

In this paper, the effect of PTS to reduce PAPR, Time delay and CFO of MC-CDMA for different modulation schemes is examined. The Pseudo random Noise sequences considered in this paper are generated. From the Matlab simulation, the results obviously shows that PAPR reduction performance depends upon various numbers of weighted phase components and it significantly improves with increase in number active users with the modulation techniques. PAPR performance is also compared for different modulation schemes (QPSK and QAM) and simultaneously for different number of users. The results show that higher PAPR reduction performance is achieved when 64 bit QPSK is used as a modulation technique than 32 QPSK, 16QPSK and QAM techniques. The results showed that PTS is more effective when 64 bit QPSK is used as modulation scheme. From the graphs it can also be concluded that PAPR reduction performance increases with increase in number of active users.

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