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PERFORMANCE OF MU-MC-DS-CDMA SYSTEM IN RAYLEIGH FADING CHANNEL

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Abstract - The Multi user Multi Carrier Direct sequencing Code Division Multiple Access (MU-MC-DS-CDMA) strategy was developed in response to rising demand for system capacity, higher data rates, and multimedia services. It's essentially a combination of CDMA and OFDM schemes. As a result, MC-CDMA takes the advantages of both CDMA and OFDM technologies. CDMA improves bandwidth consumption performance, whereas OFDM helps to minimize Inter Symbol Interference (ISI) and multipath fading. This dissertation suggests a method for evaluating the performance of multi user MC-DS-CDMA system. BER and PAPR are used to evaluate the results. The Bit Error Rate (BER) output of the proposed method is then examined using MATLAB for various modulation techniques. By using Walsh-Hadamard (W-H) code is used because it eliminates Multiple Access Interference (MAI). In terms of BER, it can be shown that BPSK performs better than QPSK.

***Key Words*:** AWGN, BER, ISI, MC-CDMA, Rayleigh Fading Channel, SNR, QPSK, MAI

1.INTRODUCTION

Code Division Multiple Access (CDMA) inherently leverages the principle of spread spectrum that has intrinsic abilities to combat against multipath interference, increases system capacity and improves quality of service. This proves the reason behind extensive use of CDMA in wireless communication. A distinctive issue present in wireless communication as compared to wired communication is multipath fading. In urban areas congested with large number of buildings, vehicles, obstacles etc. results in reflection, refraction, deflection and scattering of transmitted radio signal which in-turn results in multiple copies of signal reaching at the receiver giving rise to multipath fading. Due to the time variant and selective nature of multipath fading at some point of time, some part of the spectrum of transmitted signal fades out at some specific location which consequently increases BER. The mobility of users (receiver) with respect to transmitter and time varying channel composed of moving obstacles make the problem of multipath inevitable. Much work has been reported till now on the calculation of average BER under different fading channel in a DS-CDMA System. Various techniques have been used to improve and analyze BER performance of CDMA system. In this paper review of such techniques has been done by categorizing them based on their line of approach while mentioning advantages, disadvantages and limitations with reasons for each of them.

In this thesis spectrum allocation technique for MC-CDMA system is evaluated for the long time evolution and Rayleigh fading channel is used for the evaluation. The targets for downlink set to 1Gbit/s and uplink data rate requirements were set to 500Mbit/s. Previously throughput technique is maximized by improved algorithm [1]. Majorly channel fading is not same for different subcarriers so that feature has been developed for allocating the subcarriers to the users according to the instantaneous channel state information (CSI) in [1] and [2]. From the reference [2]. ACA is proposed for maximizing throughput in which subchannels are divided into groups, these groups are allocated depending upon the user requirement. And in that paper channel fading feature is not fully developed. In [3] other subcarrier selection techniques are discussed by dividing the spectrum allocation techniques by two ways that is single channel allocation and group channel allocation. In [5] selected number of sub carriers is assigned to each user. The concept is to assign each user only as many sub-carriers as are needed to support the user’s data rate. For addition of every filter for subcarrier selection the complexity of the system increases. Channel state information refers to amount of channel fading user experiences on particular channel. Some schemes have been proposed for sub carrier selection according to CSI which includes, selecting the sub carrier requiring least amount of transmit power on it. In this paper how to require least amount of transmit power is evaluated for selecting a subcarrier is discussed. For improvement in BER performance, high data throughput in a multi-cell environment, reducing the consume high power at the mobile terminal, and results in high spectrum efficiency these results must shown by an appropriate sub-carrier selection technique. For the given power, throughput can be maximized by assigning maximum number of sub carriers to the users.

OFDM and CDMA techniques are used in high speed wireless communications. One of the advanced techniques for broadband wireless communication is Multi-Carrier Code Division Multiple Access (MCCDMA) [2]. MC-CDMA system benefits from the robustness of OFDM against multipath environment and from the capability of multiuser multiplexing services that is achieved via (CDMA) system [2, 3].

2 MULTIPLE ACCESS TECHNIQUES

For some circumstances the cost become very high or setting base stations become not useful practically , so we need techniques that keep our spectrum efficiently or increase it's capacity , that all lead to develop the multiple access schemes. In the mobile communications enormous number of users connect to the same point and through it , simply this is the concept of multiple . Users here share the same base station , and the scheme type will be specified according to one of following domains : a- frequency b- time c- code every single one will produce different scheme so that we have FDMA (frequency division multiple access) , TDMA (time division multiple access) , CDMA (code division multiple access) . [12]

3 CDMA

Code division multiple access (CDMA) is a multiple access technique where different users share the same physical medium, that is, the same frequency band, at the same time. The main ingredient of CDMA is the spread spectrum technique, which uses high rate signature pulses to enhance the signal bandwidth far beyond what is necessary for a given data rate[3]. In a CDMA system, the different users can be identified and, hopefully, separated at the receiver by means of their characteristic individual signature pulses (sometimes called the signature waveforms), that is, by their individual codes. CDMA is a form of "spread-spectrum" signaling, since the modulated coded signal has a much higher data bandwidth than the data being communicated. Nowadays, the most prominent applications of CDMA are mobile communication systems like cdma One (IS-95), UMTS or cdma2000. CDMA is a spread spectrum multiple access technique.

CDMA is a technique where the narrowband user signal multiplied by a wideband code , and the codes are orthogonal to each other in the cell. For any single user the coded messages of the remaining users will appear as noise in the back of the received signal. According to that users here can share the same frequency and the same time domain of the cell. Figure 1.4 below describe the CDMA concept according to the code , time , and bandwidth. Ever since increasing the number of users will increase the noise inside the cell , then the cell can take unlimited number of users under a condition that SNR stay correctable , this is considered a CDMA capacity limitation. Nevertheless CDMA still so preferred access technique because it spread the message bandwidth throughout a finite spectrum of the cell. After transmission the signal will look distorted because the message power will be so low compared to the noise power, this is considered a very important security feature of CDMA scheme. For the sake of decoding a message, the receiver must already know the spreading code that treated the message. Some of the common orthogonal spreading codes are: PN sequences, Walsh, and Gold code. [2]

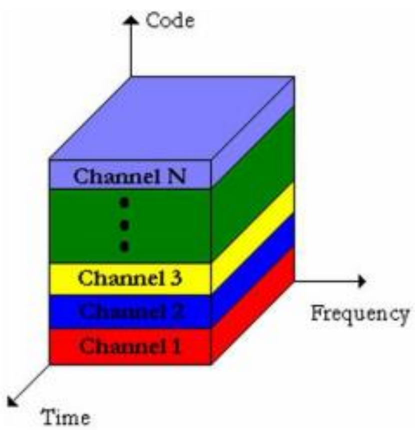

Figure 2: CDMA concept

In CDMA, a locally generated code runs at a much higher rate than the data to be transmitted. Data for transmission is simply logically XOR (exclusive OR) added with the faster code. The figure shows how spread spectrum signal is generated. The data signal with pulse duration of Tb is XOR added with the code signal with pulse duration of Tc[5]. (Note: bandwidth is proportional to 1 / T where T = bit time) Therefore, the bandwidth of the data signal is 1 / Tb and the bandwidth of the spread spectrum signal are 1 / Tc. Since Tc is much smaller than Tb, the bandwidth of the spread original signal. CDMA uses Direct Sequence spreading, where spreading process is done by directly combining the baseband information to high chip rate binary code.

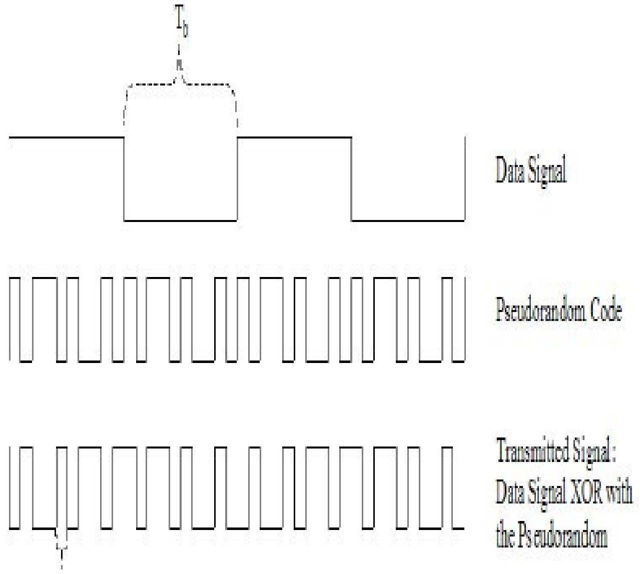

Figure 1: CDMA transmitted signal

Each user in a CDMA system uses a different code to modulate their signal. Choosing the codes used to modulate the signal is very important in the performance of CDMA systems. The best performance will occur when there is good separation between the signal of a desired user and the signals of other users. The separation of the signals is made by correlating the received signal with the locally generated code of the desired user. If the signal matches the desired user's code then the correlation function will be high and the system can extract that signal. If the desired user's code has nothing in common with the signal the correlation should be as close to zero as possible (thus eliminating the signal); this is referred to as cross correlation[2]. If the code is correlated with the signal at any time offset other than zero, the correlation should be as close to zero as possible. This is referred to as auto-correlation and is used to reject the multipath interference. Figure shows the view of CDMA users.

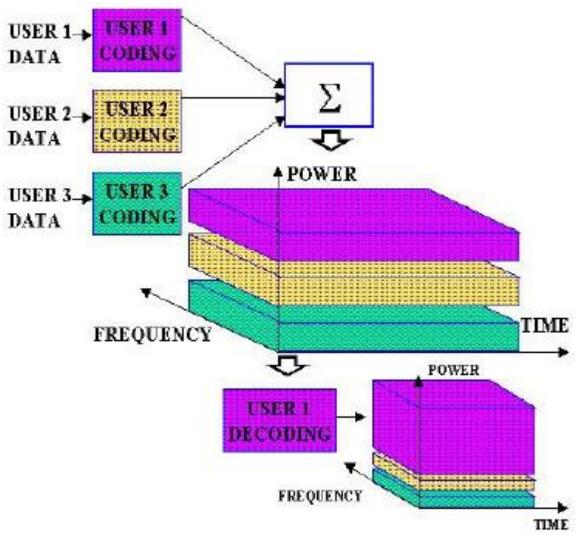

Figure 3: View of CDMA Users

4. NEED OF MC-CDMA

MC-CDMA employ the benefits of both OFDM and CDMA and forms an efficient transmission system by the spreading of input data symbols through spreading codes in frequency domain. The amount of narrowband orthogonal subcarriers through symbol period longer than the delay spread and each subcarrier are affected by similar deep fades by the channel at the same time cause enhance the performance. Adding to the number of path will enhance the performance of system this is enhanced mainly by two reasons firstly due to diversity, then, it decline due to the increase in the interference from various paths at all users. Generally, there are proficient number of paths that based on the system to be used and the number of users. Interference will be increased with the number of users through all the paths. So, the best possible number of paths decreased.

In MC-DS-CDMA, for a given transmission bandwidth, small numbers of sub-carriers can generally be considered since the sub-carriers are disjoint and individually spread. This results in a lower PAPR than in MC-CDMA for the same transmission bandwidth because of the smaller number of sub-carriers. The low PAPR property and the capability to handle asynchronous transmissions make MC-DS-CDMA suitable for the asynchronous uplink of mobile radio communication systems 4 [6]. The principle of MC-DS-CDMA time domain spreading is illustrated in Figure.

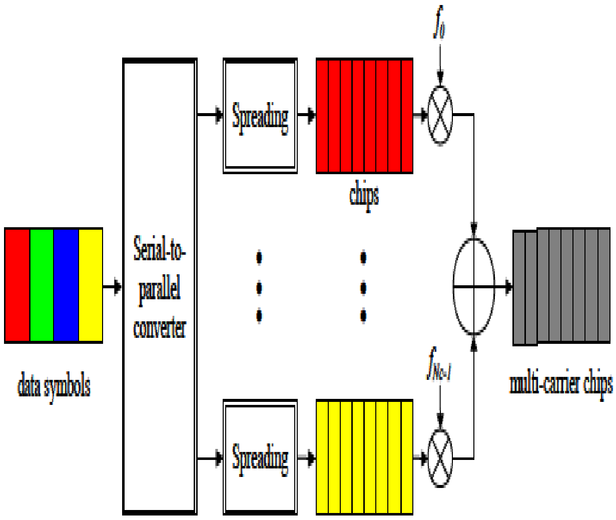

Figure 4: Principle of MC-DS-CDMA time domain spreading

In the new proposed technique the spreading is done in frequency domain while the despreading at the receiver is doing in time domain and the channel estimation and compensation are the same, but they are performed after the output of the IFFT (New Block) at the receiver.

MC-CDMA scheme spreads the original data on large bandwidth by using a given spreading code and converts the high rate of serial stream to parallel low rate sub stream then transmits N chips simultaneously by assigning each chip to a separate carrier, by using OFDM transmitter, so that each input symbol is transmitted on N subcarriers. By correlating the signal samples at the OFDM output with the code sequence used for signal dispreading, the transmitted symbol will be extracted at the output of the receiver.MC-CDMA transmitter system is shown by figure , where aB[i] represents binary data input sequence belong to the uth user at ith time.

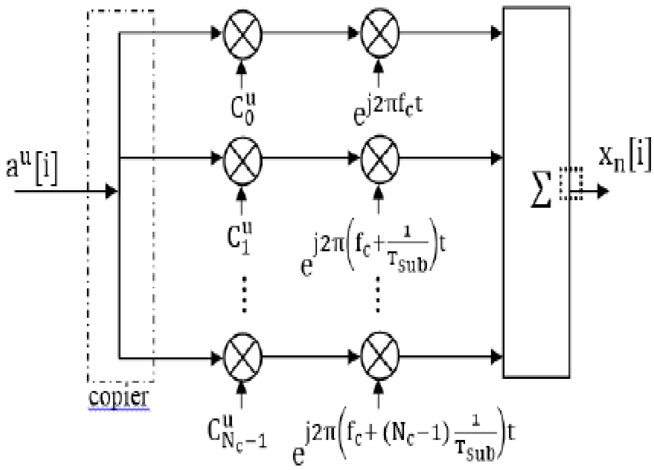

Figure 5: MC-CDMA transmitter

Considering the case where the length of processing gain PG is equal to the number of subcarrier Nc(Nc=PG), the ith input dataaB[i], is first copied to Nc subchannels and then multiplied by the spreading code Cm which corresponds to the uth user, modulated by Nc subcarriers, then summed and digitized to generate the transmitted MC-CDMA signal xI[i] which is given by [9].

$$x_n[i] = \sum_{n=0}^{Nc-1} X_m[i] e^{\frac{j2\pi mn}{Nc}} \quad , n = 0,1, \ldots, Nc-1$$

Where

$$X_m[i] = \sum_{u=0}^{U-1} a^u[i]\, C_m^u$$

Where spreading code given by

$$C_m^u = C_0^u, C_1^u, \ldots, C_{P_G-1}^u$$

The transmitted signal, xn[i] in equation has a similar formula as that of the OFDM transmitted signal,except that it contains the multiuser multiplexing capability which is introduced basically by the CDMA technology. For simplicity, the index (i) could be omitted in case of one OFDM symbol and assuming multipath fading channel consists of L-paths, then the received signal is given by .

$$y_n = \sum_{l=0}^{L-1} h_{n,l}\, x_{n-l} + w_n$$

Where hn,l represents the channel impulse response of the *l*thpath at time n and wI is the noise component. Without inter carrier interference(ICI),the received signal in the frequency domain is given by (8):

$$Y_m = \left[\sum_{l=0}^{L-1} H_l^0 e^{-\frac{j2\pi lm}{N_c}}\right] X_m + W_m$$

$$= \alpha_m X_m + W_m$$

Where WG is the noise component in frequency domain, L represents the number of paths, and α G represents the multipath fading effect and is given by

$$\alpha_m = \sum_{l=0}^{L-1} H_l^0 e^{-\frac{j2\pi lk}{N_c}}$$

Where H^{-1} represents the channel transfer function. If the channel is assumed to be time invariant during the symbol period, then it could be easily compensated by frequency domain equalizer, where the output of the equalizer is given by.

$$X = H^{-1} Y^T$$

Where$H^{-1}$is the estimated inverse channel transfer function. Based on equations figure shows the channel estimation and equalization system for MC-CDMA receiver

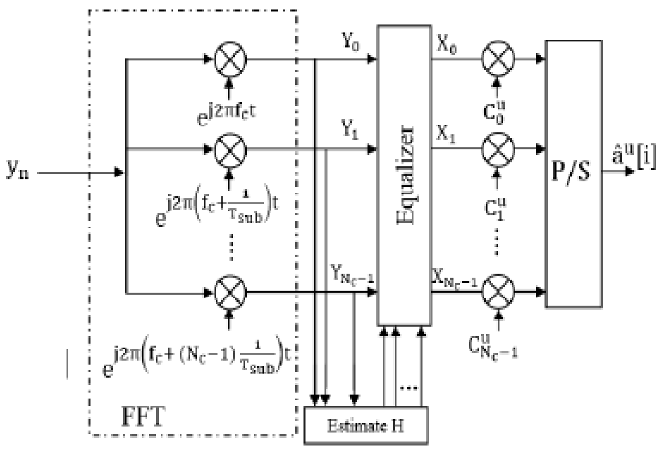

Figure 6: MC-CDMA receiver

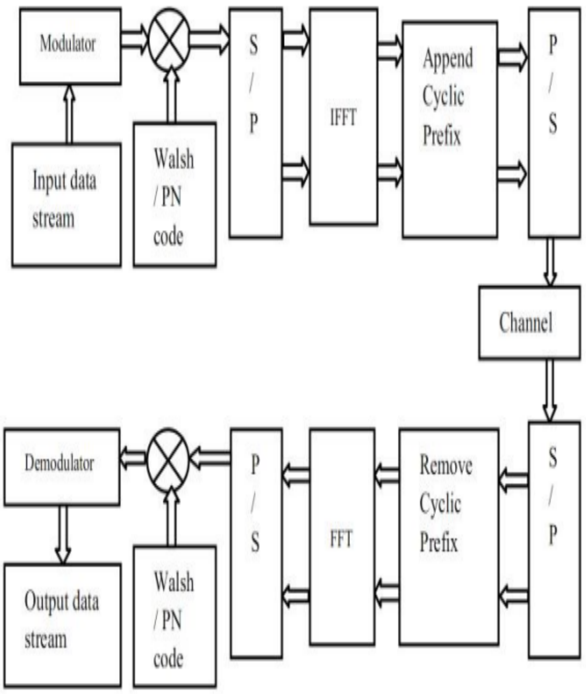

Figure 7: Block diagram of Proposed Method

5. SIMULATION RESULTS

The combination of conventional MC-CDMA with the proposed Method was studied, the Walsh-Hadamard have been used. The simulation of the two systems have been made using MATLAB, and the BER performance of the systems was studied in different channel models which are AWGN, flat fading channel.

MC-CDMA System Performance over Rayleigh and AWGN Channel the results when Rayleigh fading is added to the channel to show the effects of this fading on the BER of the system. In this paper the Rayleigh fading has four taps with different powers. The following results show that the fading affects the characteristics of the system sharply and clearly. Figure shows the effect of Rayleigh fading channel on MC-CDMA system has four users each one sends ten thousand bits on the channel. The data were spreaded using 4-bit PN code and modulated using Binary Phase Shift Keying modulation. PN code with 16 bits is used to spread the data of the every user in MC-CDMA system. Ten thousands of data are sent for each SNR value and the BER plot is shown in Figure. The system has 16 users broadcasting on the Rayleigh fading channel.

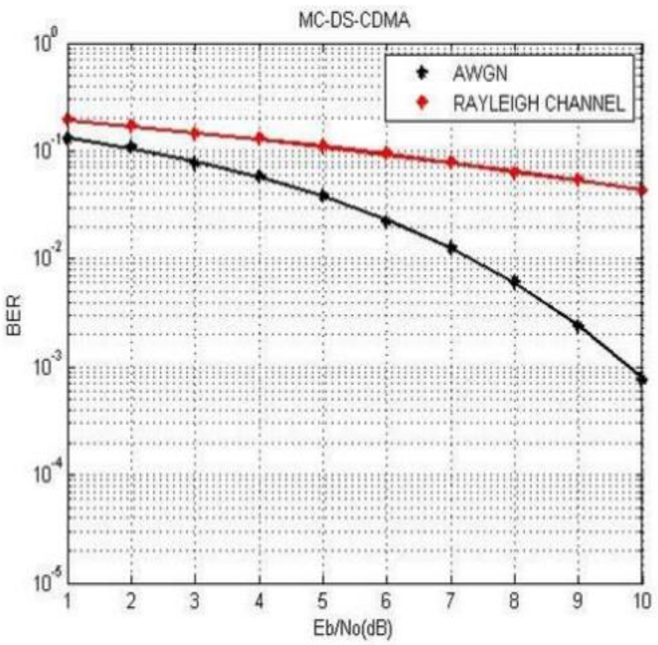

Figure 8: Shows the comparison of BER of Rayleigh and AWGN Channel

Figure shows the plot of BER for user 4, 16, 32 for different values of SNR. This MC-CDMA system has 32 users sending and receiving data on Rayleigh fading channel. Each user sends and receives 10000 bits with 32-bit PN code and BPSK modulation. For each SNR between 0 dB and 50 dB the BER values is plotted to show the effect of Rayleigh fading channel on MC-CDMA system has 64 users, every user has 10000 bits. The data were spread using 64-bit PN code and modulated using Binary Phase Shift Keying modulation. BER plot is shown in figure.

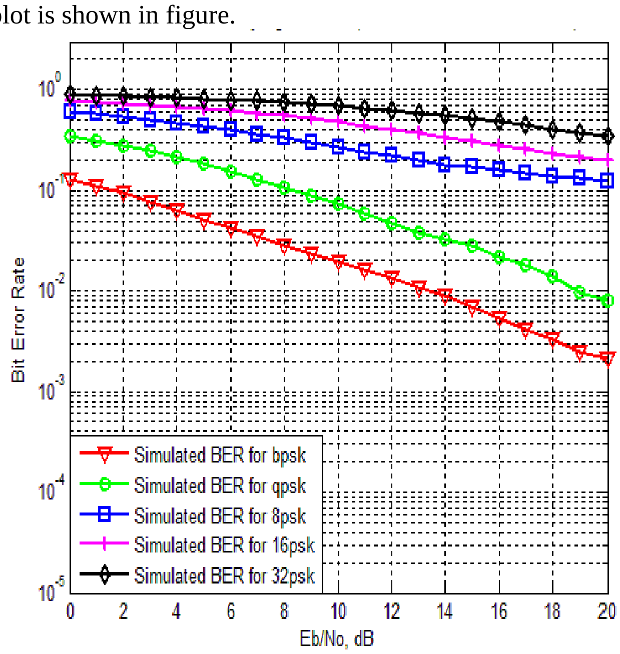

Figure 9: BER with different order of BPSK modulation

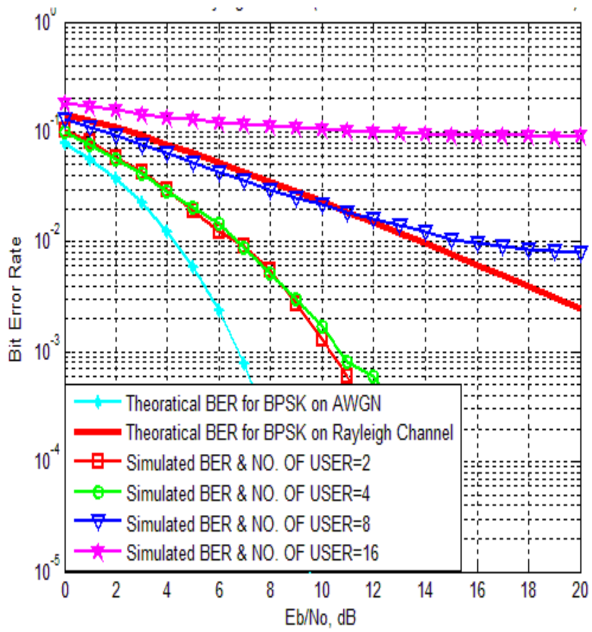

Figure 10: BER for different user with BPSK modulation

Bit error rate is direct proportional with the number of users. Therefore increasing the number of users will increase the required value of SNR to get a secure system with a minimum number of errors. A comparison for the performance of MC-CDMA for different Number of sub-carriers (under AWGN and Rayleigh fading channel) is shown in Figure.

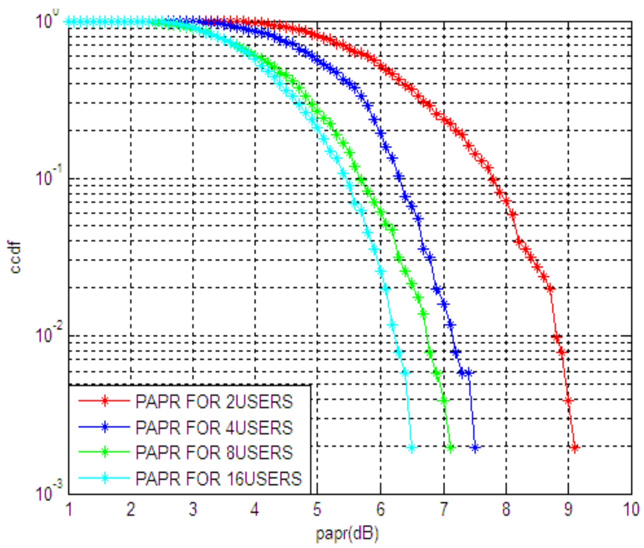

Figure 11: PAPR for different numbers of users with BPSK modulation

TABLE 1: OBSERVATION TABLE FOR RELATION BETWEEN PAPR AND NUMBER OF USERS

S.no.	Different Channel	Two Users	Four Users	Eight Users	Sixteen Users
1.	AWGN Channel (Existing Algorithm)	9.8 dB	8.2dB	7.8 dB	7.1 dB
2.	AWGN Channel(Proposed Algorithm)	8.5dB	7.5dB	7.1dB	6.5dB

6. CONCLUSION & FURTURE SCOPE

The combination between OFDM technology and CDMA technology resulting an attractive high speed wireless MC-CDMA communication system. The obtained results shown that the performance of the MC-

One main drawback of any kind of multicarrier modulation is the inherent high value of the Peak-to-Average Power Ratio of the transmitted signals, because they are generated as an addition of a large number of independent signals. Therefore, low power consumption at the transmitter is a strict requirement. Once the RF High Power Amplifier (HPA) is to operate with a low back-off level (i.e. with operation point near saturation state); signal peaks will frequently enter the nonlinear part of the input-output characteristic of the HPA, thus causing severe nonlinear artifacts on the transmitted signals such as inter-modulation Distortion and out-of-band radiation, Therefore, reducing the PAPR is crucial in multicarrier systems. So future research focus on PAPR reduction techniques in MC CDMA.

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