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Performance Analysis of Multicarrier Code Division Multiple Access Transmission Techniques using BPSK Modulation

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***Abstract*-Future wireless communication systems must be able to accommodate a large number of users and simultaneously to provide the high data rates at the required quality of service. Multi-carrier code division multiple access(MC-CDMA) is a promising technique for future 4G broadband multiuser communication systems.MC-CDMA is a combination of orthogonal frequency-division multiplexing(OFDM) and code division multiple accesses (CDMA), it has been considered as an important technique for the future generation wireless systems due to its combined advantages of MC and CDMA techniques: high spectral efficiency, robustness in frequency selective channels with a low-complexity at receiver considering a simple one-tap equalization, multiple access capability with high flexibility, narrow-band interference rejection.**

The aim of this paper is to study the performance of MC-CDMA under the effect of Rayleigh fading channel and Additive White Gaussian Noise (AWGN) using MATLAB.

Keywords—Multi-carrier code division multiple access (MC-CDMA), Orthogonal frequency division multiplexing (OFDM), Binary phase shift key (BPSK), Peak to average power ratio (PAPR), Additive white Gaussian noise (AWGN), Rayleigh fading.

I. INTRODUCTION

Today, the enormous increase in demand for high-speed data transmission by many wireless multi-media services pushes the development of advanced modulation and multiple access techniques that can provide reliable and high data rate transmission with high bandwidth efficiency and strong immunity to multi-path distortion.

OFDM has drawn considerable attention in high speed mobile communications due to its bandwidth efficiency, frequency diversity, and immunity to channel dispersion during the last decade. Currently, OFDM is being used in digital audio and video broadcasting, wireless local/metropolitan area networks, and asynchronous digital subscriber lines (ADSL). With recent advances in modulation and multiple access techniques, OFDM becomes more and more popular [1].

Recently, different combinations of OFDM and code division multiple accesses CDMA have been reported. In particular, in [2], Singh G.discussed BER performance comparison between CDMA and MC-CDMA in three multipath fading channels: Rayleigh, Rician and Nakagami channels, in [3], M.F. Ghanim compared between the effect of AWGN and Rayleigh channel with AWGN on MC-CDMA system, in [4] Sarala B. studied and analyzed BER performance of MC-CDMA for different spreading sequences (Walsh codes, Gold codes and Maximal length Pseudo Noise codes) at AWGN and Rayleigh fading channel. One of these combinations is the MC-CDMA technique, which has been considered as an important technique for the fourth-generation wireless systems [5].

In this paper, we examine the bit error rate (BER) performance of MC-CDMA system in AWGN and a Rayleigh channel under different conditions (Modulation order, multiuser interference (MUI) and different number of sub-carriers) and we also analyze the effect of multiuser and different number of sub-carriers on PAPR of MC-CDMA System. The rest of the paper is organized as follows. Section II reviews background on OFDM. Section III explains the MC-CDMA system model. Section IV introduces Walsh codes as a spreading sequence, Section V shows channel modeling. Simulation results are reported in section VI. Finally, Conclusions and future work are presented in Section VII.

II. OFDM

Recently, there has been an increasing demand for multimedia transmission in mobile communication system. In order to provide such multimedia services with high speed transmission and higher bandwidth efficiency, OFDM is expected to be an appropriate scheme [6][7]. OFDM is one of the approaches for integrating 4G in existing mobiles [8].

The mobile communication channel is susceptible to multi path fades due to a large number of scatterers and reflectors. Diversity techniques are used to mitigate the effects of the multipath phenomenon [9]. One of the solutions to combat Inter Symbol Interference (ISI) - result from multi path fading - is multi-carrier modulation for data transmission [10].In OFDM, transmission is carried out in parallel on the different frequencies. That is, the entire channel is divided into many narrow band sub-channels, which are transmitted in parallel, thereby, increasing the symbol duration and reducing the ISI. The carrier spacing is selected such that modulated carriers are orthogonal over a symbol interval. In addition a guard interval (cyclic prefix) is inserted in order to combat the frequency selectivity of the channel [11]. Therefore, it reduces multipath fading without having to provide powerful channel equalization [8]. Although OFDM enables simple equalization, it is sensitive to carrier frequency offset and suffers from the fact that the peak to average ratio (PAR) of the transmitted signal power is large [10].

A. peak to average power ratio in OFDM

Now the Peak to Average Power Patio (PAPR) of a transmitted signal can be calculated using equation (1)

$$PAPR(x) = 10\, log_{10}\left[\frac{\underset{0\leq n<N-1}{MAX}|x(n)|^2}{E[|x(n)|^2]}\right] \quad (1)$$

This is defined as the ratio between the square of the maximum power and square of the average power of the signal. However, in order to observe the PAPR performance of a signal, the Cumulative Distributed Function (CDF) or the Complementary Cumulative Distribution function (CCDF) is used. Through the CCDF, it can be observed that the PAPR of the signal exceeded a certain value.

The CCDF plots offer a comprehensive analysis of signal power peaks. “It is a statistical technique that provides the amount of time, a signal spends above any given power level”. However by using these plots, a probability can be seen that a signal data block exceeds a given threshold. These CCDF plots can be used to analyze the PAPR performance of signals.

In order to calculate the CCDF of a given data, the following steps should be followed:

1. Calculate the Probability density function (PDF) of the data
2. Take the integral of the PDF to get the Cumulative Distributed Function (CDF)
3. Subtract the CDF from "1"to get the CCDF

From the central-limit theorem, for large values of N_{FFT}, the real and imaginary values of the transmitted signal would have Gaussian distribution. Consequently, the amplitude of the OFDM signal has a Rayleigh distribution with zero mean and a variance of N_{FFT} times the variance of one complex sinusoid. Assuming the samples to be mutually uncorrelated, the CCDF for the peak power per OFDM symbol is given by, [12] [13]:

$$\mathrm{P}(\mathrm{PAPR} > z) = 1 - (\mathrm{PAPR} \leq \mathrm{z}) = 1 - \mathrm{F(z)}^{\mathrm{N}} = 1 - (1 - \exp(-\mathrm{z}^2))^{\mathrm{N}} \quad (2)$$

From equation (2), it can be seen that a large PAPR occurs only infrequently due to relatively large values of N_{FFT}, used in practice.

Where:

- *$F(z)$... is the CDF.*
- *Z... is the threshold*
- *N...total number of subcarriers*

The PAPR is very sensitive regarding number of carriers used for data transmission. Namely, by increasing the number of subcarriers used for data transmission, the maximal signal value increases and causes high PAPR [14].

III. MC-CDMA SYSTEM MODEL

In MC-CDMA, instead of applying spreading sequences in the time domain, we can apply them in the frequency domain, mapping a different chip of a spreading sequence to an individual OFDM subcarrier. Hence each OFDM subcarrier has a data rate identical to the original input data rate and the multicarrier system “absorbs” the increased rate due to spreading in a wider frequency band.

A. MC-CDMA transmitter scheme

The transmitted signal of the i^{th} data symbol of the j^{th} users$_i^j$(t) is written as:

$$s_i^j(t) = \sum_{k=0}^{N-1} b_i^j c_k^j e^{2\pi(f_o+kf_d)t} p(t - iT) \quad (3)$$

Where

- N … is the number of subcarriers
- b_i^j … is the ith message symbol of the jth user
- c_k^j… represents the kth chip, $k = 0, \ldots, N-1,$ of the spreading of the jth user
- f_o… is the lowest subcarrier frequency
- f_d… is the subcarrier separation
- $p(t)$… is a rectangular signalling pulse shifted in time given by:

$$p(t) = \begin{cases} 1, & for\ 0 \leq t \leq T \\ 0, & Otherwise \end{cases} \quad (4)$$

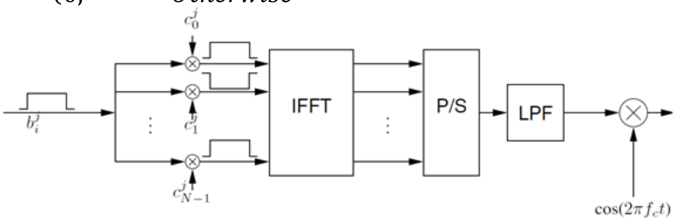

Fig. 1. MC-CDMA transmitter

The principle of MC-CDMA is to map the chips of a spread data symbol in frequency direction over several parallel sub-channels.

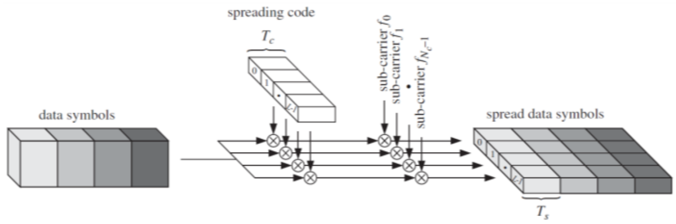

Fig. 2. MC-CDMA signal generation for one user

MC-CDMA transmits a data symbol of a user simultaneously on several narrowband Sub-channels. These sub-channels are multiplied by the chips of the user-specific spreading code, as illustrated in the above Fig. 2. Multi-carrier modulation is realized by using the low complex OFDM operation. Since the fading on the narrowband sub-channels canbe considered flat, simple equalization with one complex-valued multiplication per sub-channel can be realized. MC-CDMA offers a flexible system design, since the spreading code length does not have to be chosen equal to the number of sub-carriers, allowing adjustable receiver complexities [15].

MC-CDMA spreads frequency bandwidth for each sub-carrier using different spreading code assigned to each user. One major advantage of MC-CDMA over Single-Carrier CDMA is that it can lower the symbol rate in each subcarrier so that longer symbol duration makes it easier to quasi-synchronize the transmission. There are several different ways in terms of combination of OFDM and CDMA to implement MC-CDMA. Nevertheless, all these systems conform to both the fundamental theory Of OFDM and CDMA [16].If the original symbol rate is high, the signal experiences frequency selective fading. Then the input data has to be serial-to-parallel converted, mapping the data to a number of reduced-rate streams before spreading over the frequency domain. This is because it is crucial for MC-CDMA signal transmission to have frequency non-selective fading over each subcarrier [17].

The spreading sequences in MC-CDMA separate other users' signal from the desired signal, provided that their spreading sequences are orthogonal to each other. Orthogonal codes have zero cross-correlation and hence they are particularly suitable for MC-CDMA [18].

B. MC-CDMA receiver scheme

The receiver structure corresponding to MC-CDMA transmitter is shown in Fig. 3, [18].

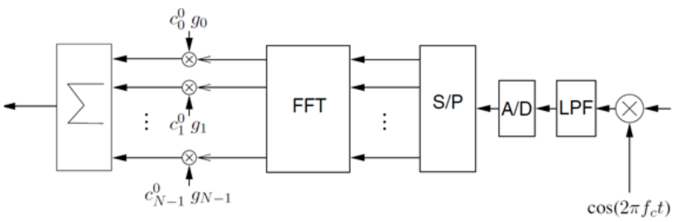

Fig. 3. Receiver schematic of MC-CDMA

At the MC-CDMA receiver each carrier's symbol, i.e. the corresponding chip c_k^j of user j, is recovered using Fast Fourier Transform (FFT) after sampling at a rate of N/Tsamples/sec and the recovered chip sequence is correlated with the desired user's spreading code in order to recover the original information, b_i^j. Let us define the ith received symbol at the kth carrierin the downlink as:

$$r_{k,i} = \sum_{j=0}^{j-1} H_k b_i^j\ c_k^j + n_{k,i} \qquad (4)$$

Where, J is the number of users, H_k is the frequency response of the kth subcarrier and $n_{k,i}$ is the corresponding noise sample. The MC-CDMA receiver of the 0-th user multiplies $r_{k,i}$ of equation (4) by its spreading sequence chip, c_k^0, as well as by the gain, g_k, which is given by the reciprocal of the estimated channel transfer factor of subcarrier k, for each received sub-carrier symbol for k=0,…,N − 1, and sums all these products, in order to arrive atthe decision variable, d_i^0, which is given by:

$$d_i^0 = \sum_{k=0}^{N-1} c_k^0 g_k r_{k,i} \qquad (5)$$

Without the frequency domain equalization of the received sub-carrier symbols, the orthogonality between the different users cannot be maintained [18].

IV. WALSHCODES SPREADING SEQUENCES

Walsh codes are generated by applying the Hadamard transform to a one by one dimensional zero matrix repeatedly. The Hadamard transform is defined as:

$$H_1 = [0]$$

$$H_{2n} = \begin{bmatrix} H_n & H_n \\ H_n & \overline{H_n} \end{bmatrix}$$

This transform gives us a Hadamard matrix, H_n, only for $n = 2^i$, where i is an integer. Hadamard matrix is a symmetric square-shaped matrix. Each column or row corresponds to a Walsh code of length n. Every row of H_n is orthogonal to all other rows. As an example, let us consider the case of n=8. We can generate 8-bitWalsh codes, H_8, applying the transform continuously from H_1three times repeatedly. The resultant matrix is as follows:

$$H_8 = \begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 1 & 0 & 1 & 0 & 1 \\ 0 & 0 & 1 & 1 & 0 & 0 & 1 & 1 \\ 0 & 1 & 1 & 0 & 0 & 1 & 1 & 0 \\ 0 & 0 & 0 & 0 & 1 & 1 & 1 & 1 \\ 0 & 1 & 0 & 1 & 1 & 0 & 1 & 0 \\ 0 & 0 & 1 & 1 & 1 & 1 & 0 & 0 \\ 0 & 1 & 1 & 0 & 1 & 0 & 0 & 1 \end{bmatrix}$$

V. CHANNEL MODELING

A. AWGN Channel

In AWGN, Gaussian noise gets directly added with the signal and information signal get converted into the noise in this model scattering and fading of the information is not considered. AWGN is a channel model in which the only impairment to communication is a linear addition of widebandor white noise with a constant spectral density (expressed as watts per hertz of bandwidth) and a Gaussian distribution of amplitude. The model does not account for fading, frequency selectivity, and interference. However, it produces simple and tractable mathematical models which are useful for gaining insight into the underlying behavior of a system before these other phenomena are considered [19].

Bit error rate for binary phase shift key in AWGN

Let us consider binary pulse amplitude Modulation (PAM) signals where the two signal waveforms are $S_1(t) = g(t)$ and $S_0(t) = -g(t)$ and $g(t)$ is an arbitrary pulse that is nonzero in the interval $0 \le t \le T_b$ and zero every elsewhere. Since $S_1(t) = -S_0(t)$, these signals are said to be antipodal. The energy in the pulse $g(t)$ is E_b . PAM signals are one dimensional, and, hence their geometric representation is simply the one dimensional vector $S_1 = \sqrt{E_b}$, $S_0 = -\sqrt{E_b}$. Fig. 4 illustrates the two signal points. Let us assume that two signals are equally likely and that signal $S_1(t)$was transmitted. Then, the received signal from the (matched filter or correlation) demodulator is

$$r = S_1 + n = \sqrt{E_b} + n$$

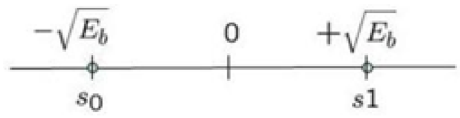

Fig. 4. Signal points for binary antipodal signals

Where n represent the additive Gaussian noise component, which has zero mean and Variance $\sigma_n^2 = \frac{1}{2}N_0$. If $r > 0$, the decision is made in favor of $S_1(t)$, and if < 0 , the decision is made that $S_0(t)$ was transmitted. Clearly, the two conditional PDFs of r are

$$p(r/s_1) = \frac{1}{\sqrt{\pi N_0}} e^{\frac{-(r-\sqrt{E_b})^2}{N_0}}$$

$$p(r/s_0) = \frac{1}{\sqrt{\pi N_0}} e^{\frac{-(r+\sqrt{E_b})^2}{N_0}}$$

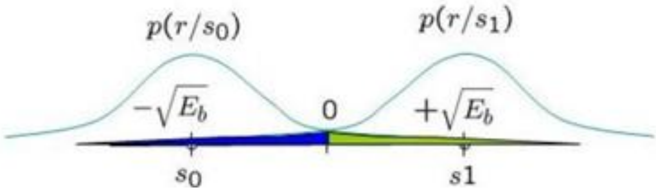

Fig. 5. Conditional probability density functions with BPSK modulation

These two conditional PDFs are shown in the above Fig. 5. Given that $S_1(t)$ was transmitted, the probability of error is simply the probability that $r < 0$, i.e.

$$P(e/s_1) = \int_{-\infty}^{0} P(r/s_1)\, dr = \int_{-\infty}^{0} \frac{1}{\sqrt{\pi N_0}} e^{\frac{-(r-\sqrt{E_b})^2}{N_0}} dr$$

$$Let\ Z = \frac{1}{\sqrt{N_0}}(r - \sqrt{E_b})\ , dr = \sqrt{N_0} dZ$$

$$P(e/s_1) = \frac{1}{\sqrt{\pi}} \int_{-\infty}^{-\sqrt{\frac{E_b}{N_0}}} e^{-Z^2} dZ = \frac{1}{\sqrt{\pi}} \int_{\sqrt{\frac{E_b}{N_0}}}^{\infty} e^{-Z^2} dZ = \frac{1}{2} erfc\left(\sqrt{\frac{E_b}{N_0}}\right)$$

Where, $erfc(x) = \frac{2}{\sqrt{\pi}} \int_x^{\infty} e^{-t^2}\ dt$ is the complementary error function. Similarly, if we assume that s_0 was transmitted, $r = -\sqrt{E_b} + n$, the probability of error given s_0 is transmitted is (the area in green region in Fig. 5):

$$p(e/s_0) = \int_0^{\infty} \frac{1}{\sqrt{\pi N_0}} e^{\frac{-(r+\sqrt{E_b})^2}{N_0}} dr = \frac{1}{\sqrt{\pi}} \int_{\sqrt{\frac{E_b}{N_0}}}^{\infty} e^{-z^2}\ dz = \frac{1}{2} erfc\left(\sqrt{\frac{E_b}{N_0}}\right)$$

Since the signals $s_1(t)$ and $s_0(t)$ are equally likely to be transmitted, the average probability of error is [20].

$$p_b = p(s_1)p(e/s_1) + p(s_0)p(e/s_0) = \frac{1}{2} erfc\left(\sqrt{\frac{E_b}{N_0}}\right)$$

$$= Q\left(\sqrt{\frac{2E_b}{N_0}}\right) \qquad (6)$$

Where, $erfc(u) = 2Q(\sqrt{2}u)$

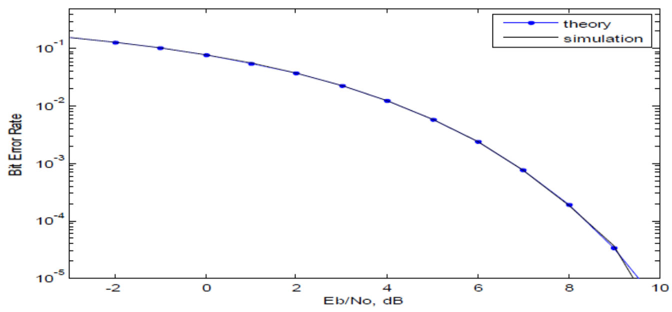

Fig. 6. BER curve for BPSK modulation

B. Rayleigh channel

In mobile radio channels, the Rayleigh distribution is commonly used to describe the statistical time varying nature of the received envelope of a flat fading signal, or the envelope of an individual multipath component. It is well known that the envelope of the sum of two quadrature Gaussian noise signals obeys a Rayleigh distribution. In wireless communication, the signal can be attenuated with time while propagating over a certain media. In wireless communication fading is mostly due to multipath propagation or shadowing which affects the wave propagation. Multipath propagation occurs when a radio signal takes two or more different paths after it is transmitted from the antenna and before its reception on the receiving antenna. There are different ways of modelling a wireless communication channel that can help in modelling the important statistical properties of real world communication systems and can also give an idea of the signal amplitudes of the transmitted signals that can be expected at the receiver side. There are different fading models that can be used to estimate the fading over a channel, e.g. Nakagami fading, Log-normal shadow fading, Rayleigh fading, Rician fading, Weibull fading etc [2].

1) Rayleigh Channel Model

Rayleigh fading is a statistical model for the effect of a propagation environment on a radio signal, such as that used by wireless devices. Rayleigh fading models assume that the magnitude of a signal that has passed through such a transmission medium will vary randomly, or fade, according to a Rayleigh distribution the radial component of the sum of two uncorrelated Gaussian random variables. Rayleigh fading is viewed as a reasonable model for tropospheric and ionospheric signal propagation as well as the effect of heavily built-up urban environments on radio signals. Rayleigh fading is most applicable when there is no dominant propagation along a line of sight between the transmitter and receiver Rayleigh fading is a reasonable model when there are many objects in the environment that scatter the radio signal before it arrives at the receiver, if there is sufficiently much scatter, the channel impulse response will be well modeled as a Gaussian process irrespective of the distribution of the individual components. If there is no dominant component to the scatter, then such a process will have zero mean and phase evenly distributed between 0 and 2π radians. The envelope of the channel response will therefore be Rayleigh distributed [19].

2) Analytical System for Rayleigh Fading Channel

In a multipath environment, it is reasonably intuitive to visualize that an impulse transmitted from transmitter will reach the receiver as a train of impulses. The Multipath Rayleigh Fading Channel implements a baseband simulation of a multipath Rayleigh fading propagation channel. This channel is useful for modeling mobile wireless communication systems. The Jakes power spectral density (PSD) determines the spectrum of the Rayleigh process. Since a multipath channel reflects signals at multiple places, a transmitted signal travels to the receiver along several paths that may have different lengths and hence different associated time delays. Fading occurs when signals traveling along different paths interfere with each other [21].

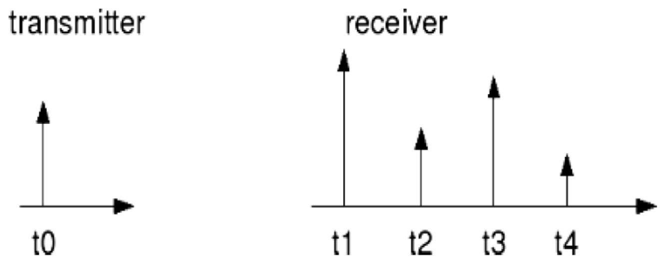

Fig. 7. Impulse response of multipath channel

Let the transmit band pass signal be:-

$x(t) = R\left(x_b(t)e^{j2\pi f_c t}\right)$
Where,

$x_b(t)\ldots$is the base band signal

f_c … Is the carrier frequency

As shown above, the transmit signal reaches the receiver through multiple paths where the ith path has an attenuation $\propto_i$ (t) and delay $\tau_i(t)$. The received signal is,

$$r(t) = \sum \alpha_i(t)x[t-\tau_i(t)]$$

Plugging in the equation for transmit baseband signal from the above equation,

$$r(t) = R\left\{\sum \alpha_i(t)x_b[t-\tau_i(t)]e^{j2\pi f_c[t-\tau_i(t)]}\right\}$$

The baseband equivalent of the received signal is,

$$r_b(t) = \sum \alpha_i(t)\, e^{-j2\pi f_c \tau_i} x_b[t-\tau_i(t)]$$
$$= \sum \alpha_i(t)\, e^{-j\theta_i(t)} x_b[t-\tau_i(t)]$$

Where, $\theta_i(t) = 2\pi f_c \tau_i(t)$ is the phase of the ith path, the impulse response is,

$$z_b = \sum \alpha_i(t)\, e^{-j\theta_i(t)} = x + jy$$

Where, z_b is complex fading coefficient, Consider a two-dimensional Gaussian process described by two random variables x and y that are transformed into amplitude z and phase θ with power spectral density (PSD) that is finite and symmetrical about frequency $\pm fc$, Let us assume the mean values for x and y are both zero and their variances are$\sigma_x = \sigma_y = \sigma$ [22], The probability density function of x is $p(x) = \frac{1}{\sqrt{2\pi\sigma^2}}e^{\frac{-x^2}{2\sigma^2}}$, The probability density function of y is$p(y) = \frac{1}{\sqrt{2\pi\sigma^2}}e^{\frac{-y^2}{2\sigma^2}}$, As x and y are independent random variables, the joint probability is the product of the individual probability i.e. $p(x,y) = \frac{1}{2\pi\sigma^2}e^{\frac{-(x^2+y^2)}{2\sigma^2}}$ [23], to convert this equation in to polar co-ordinate we follow these steps,

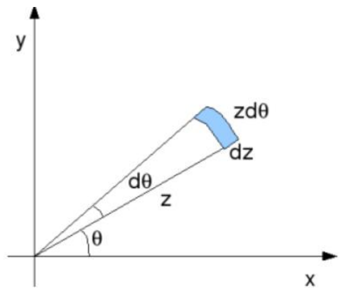

Fig. 8. Cartesian co-ordinate to polar co-ordinate

Given that (x,y) is in the Cartesian co-ordinate form, we can convert that into the polar co-ordinate (Z,θ) where, Z=$\sqrt{x^2+y^2}$, $\theta = \tan^{-1}\left(\frac{y}{x}\right)$

Joint distribution of the channel fading coefficient in terms of Z and θ equal as shown below: - [24] [22]

$$\therefore\ p(Z,\theta) = \begin{cases} \frac{z}{2\pi\sigma^2}e^{-\frac{z^2}{2\sigma^2}} & 0 \le z, -\pi \le \theta \le \pi \\ 0, & Otherwise \end{cases} \quad (7)$$

The PDF of the envelope of the Gaussian noise P(Z)is:-

$$p(Z) = \begin{cases} \frac{z}{\sigma^2}e^{-\frac{z^2}{2\sigma^2}} & Z \ge 0 \\ 0, & Otherwise \end{cases} \quad (8)$$

A PDF sketch of the envelope P(Z)is shown in Fig.9.

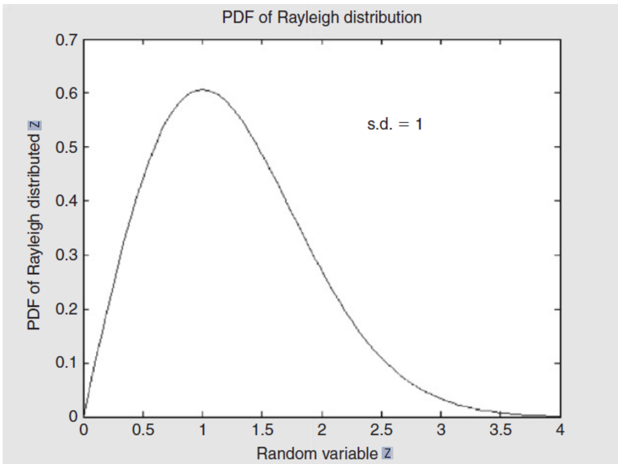

Fig. 9. PDF of Rayleigh distribution standard deviation=1

The PDF of θ denoted P (θ) has uniform distribution between $\theta = -\pi$ and $\theta = \pi$ and is given by:-

$$P(\theta) = \begin{cases} \frac{1}{2\pi} & \text{for } -\pi \le \theta \le \pi \\ 0, & Otherwise \end{cases} \quad (9)$$

A sketch of P(θ)is shown in Fig.10.

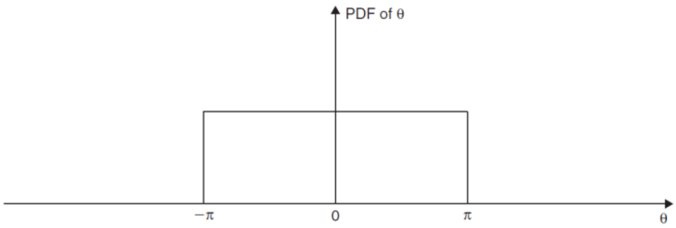

Fig. 10. P(θ) Verses θ

3) *BER for BPSK in Rayleigh fading channel*

In order to get the bit error rate for BPSK with Rayleigh fading channel which is of the form $y = zx + n$, assume that the channel is flat fading and is randomly varying in time. The noise, n has the Gaussian probability density function which, is given by equation $p(n) = \frac{1}{\sqrt{2\pi\sigma^2}} e^{\frac{-(n-\mu)^2}{2\sigma^2}}$

This Equation $P_b = \frac{1}{2}\text{erfc}\left(\sqrt{\frac{E_b}{N_0}}\right)$ gives the Bit error probability, however the presence of channel z, the effective bit energy to noise ratio is $\frac{|z|^2 E_b}{N_0}$. So the bit error rate probability for a given value of z is given by,

$$P_{b/z} = \frac{1}{2} erfc\left(\sqrt{\frac{|z|^2 E_b}{N_0}}\right)$$
$$= \frac{1}{2} erfc(\sqrt{\gamma}) \qquad (9)$$

Where, $\gamma = \frac{|z|^2 E_b}{N_0}$, So the error probability is given by,

$$P_b = \frac{1}{2}\left(1 - \sqrt{\frac{\left(\frac{E_b}{N_0}\right)}{\left(\frac{E_b}{N_0}\right) + 1}}\right) \qquad (10)$$

From above equation we can draw the bit error rate curve for BPSK using Rayleigh channel [25].

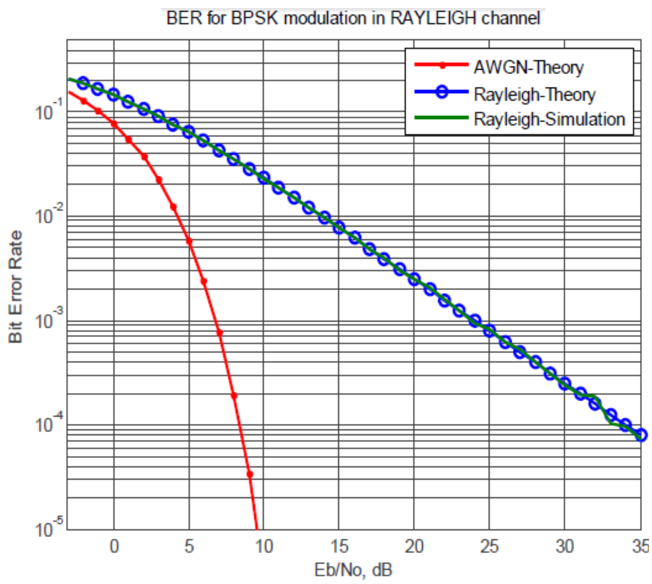

Fig. 11. Comparison between AWGN and Rayleigh channel BER for BPSK

VI. SIMULATION RESULTS

The MC-CDMA proposed system is simulated using Matlab environment. The system was simulated over Rayleigh Fading and AWGN channel model to show the effect of its bit error rate relating to signal to noise ratio.

Phase shift keying (PSK) is widely used these days within a whole communications system. It is particularly well suited to the growing area of data communications. PSK, phase shift keying enables data to be carried on a radio communications signal in a more efficient manner some other forms of modulation.

The following simulation parameters are set for the simulation of the system.

OFDM symbol=512.
Cyclic prefix=4.
Number of Bits: 10000
AWGN Channel Parameters
SNR (minimum): 0 dB
SNR (maximum): 20 dB
Rayleigh Fading Channel Parameters
Number of Paths: 4
Gains of Path: 0.2174, 0.3913, 0.3043, 0.0870

A. *PSK Modulation Order*

This section discusses the effect of modulation order (PSK) on MC-CDMA system

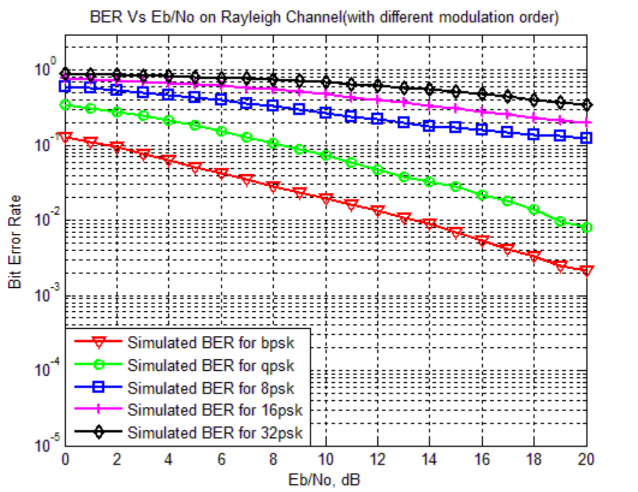

Fig. 12. SNR/BER for 2 users and 4 sub-carriers with different order of PSK modulation

BER is the key parameter for indicating the system performance of any data link. The BER increases for high order modulation (PSK) in MC CDMA used in LTE system. On the other hand, the lower order modulation scheme (PSK) experience less BER at receiver thus lower order modulations improve the system performance in terms of BER and SNR. If we consider the bandwidth efficiency of these modulation schemes, the higher order modulation accommodates more data within a given bandwidth and is more bandwidth efficient as compare to lower order modulation. Thus there exists a tradeoff between BER and bandwidth efficiency among these modulation schemes used in LTE.

We also conclude from our results that, the error probability increases as order of modulation scheme increases. Therefore the selection of modulation schemes in adaptive modulation is quite crucial based on these results.

B. BER over AWGN and Rayleigh Fading Channel

This section discusses BER of different users over AWGN and Rayleigh fading channel when modulation and sub carriers are fixed. In this paper the Rayleigh fading consider during simulation has four taps with different powers.

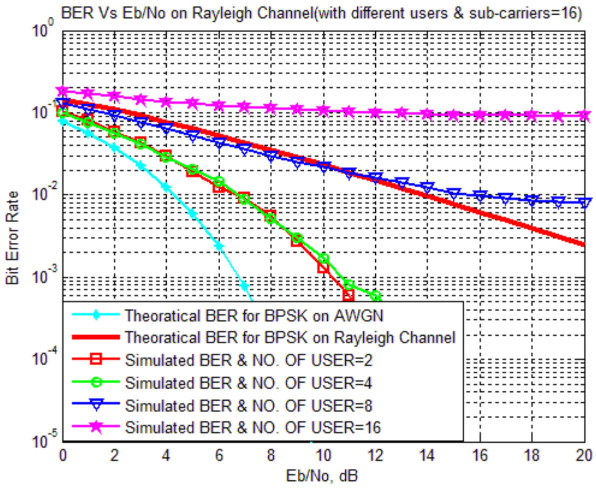

Fig. 13. SNR/BER for different user and16 sub-carriers with BPSK modulation

Bit error rate is direct proportional with thenumber of users. Therefore increasing the number of users will increase the required value of SNR to get a secure system witha 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 Fig. 14.

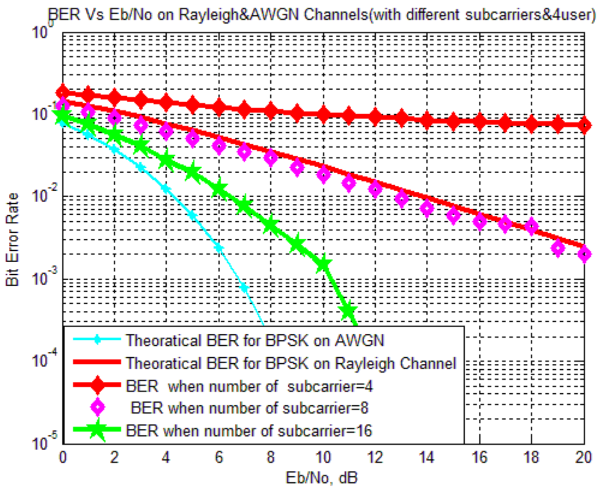

Fig. 14. SNR/BER for different sub-carriers and fixed users with BPSK modulation

A simulation result shows that the increase in sub-carriers decreases the effects of multipath fading. As the comparison in the Fig. 14, Results significant reduction on BER curve with higher sub-carriers i.e. the number of subcarriers increases to reduce BER and provides quality of Service.

C. PAPR in MC-CDMA

1) PAPR and sub-carriers

The power consumption at the user end such as portable devices is again a vital issue for uplink transmission in MC-CDMA (LTE) system From our simulation we study The effect of increasing sub-carriers on PAPR. Fig. 15 show CCDF of PAPR of MC-CDMA for different numbers of sub-carriers where BPSK is used as a modulation technique

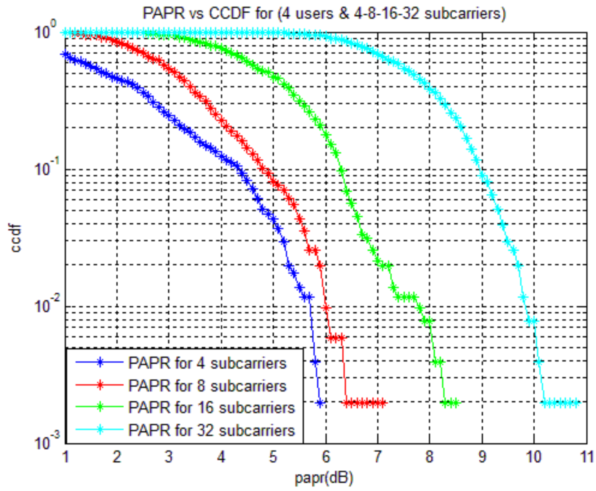

Fig. 15. CCDF/PAPR for different sub-carriers and fixed users with BPSK modulation

From Fig. 15table I can be deduced.

TABLE I. OBSERVATION TABLE FOR RELATION BETWEEN PAPR AND NUMBER OF SUBCARRIERS

Used Parameter	CCDF	Four Subcarriers	Eight Subcarriers	Sixteen Subcarriers	Thirty-two Subcarriers
BPSK Modulation with AWGN Channel& Rayleigh channel	10^{-1}	4.4dB	4.8dB	6.25dB	8.9 dB
	10^{-2}	5.75 dB	6 dB	7.8 dB	9.8 dB

As shown in Fig. 15 and table I that PAPR is increasing with increasing the numbers of sub carriers.

2) PAPR and user's numbers

This section discusses the effect of increasing number of users on PAPR when the numbers of subcarriers are fixed.

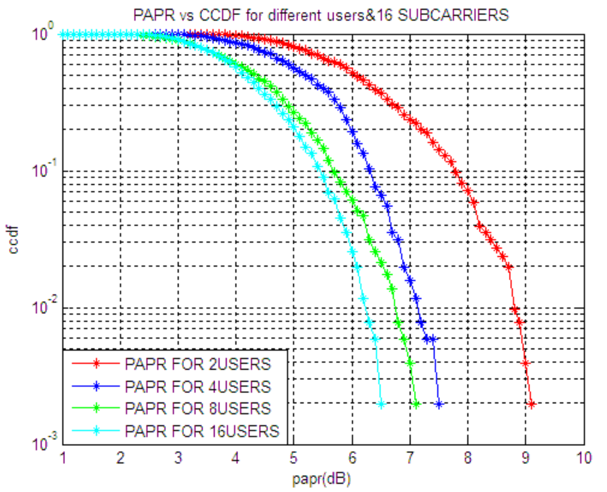

Fig. 16. CCDF/PAPR for different numbers of usersand fixed numbers of sub-carriers with BPSK modulation

TABLE II. OBSERVATION TABLE FOR RELATION BETWEEN PAPR AND NUMBER OF USERS

Used Parameter	CCDF	Two Users	Four Users	Eight Users	Sixteen Users
BPSK Modulation with AWGN & Rayleigh channel	10^{-1}	7.8 dB	6.3 dB	5.7dB	5.5 dB
	10^{-2}	8.8 dB	7.2 dB	6.8 dB	6.2dB

From result of simulation, when the numbers of users are increasing, PAPR is decrease in MC-CDMA System

VII. CONCLUSIONS AND FUTURE WORK

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, especially when transceivers are fed by batteries (such as in mobile devices), so future research focus on PAPR reduction techniques in MC CDMA.

REFERENCES

[1] GJe-hong Jong, "Performance Analysis of Coded Multicarrier Spread-Spectrum Systems in the Presence of Multipath Fading and Nonlinearities", IEEE Communication Magazine, vol. 49, pp. 168-179, January 2001.

[2] Gagandeep Singh Dhaliwal and NavpreetKaur, "BER based Performance Analysis of MC CDMA over Multipath Channels", International Journal of Computer Applications, Vol. 69– No.22, May 2013.

[3] M.F. Ghanim and M.F.L.Abdullah, "Multi-User MC-CDMA using Walsh Code for Rayleigh and Gaussian Channel ",IEEE Student Conference on Research and Development, 2011

[4] Sarala B and Venkateshwarulu D.S, "performance Analysis of Multicarrier Code Division Multiple Access Transmission Techniques", 5th International Conference on Information Processing ,Bangalore, India, August 2011.

[5] Li-Chun Wang, and Chih-Wen Chang, "On the performance of multicarrier DS-CDMA with imperfect power control and variable spreading factors", IEEE Communication Magazine, vol. 24, pp. 1154–1166, June 2006.

[6] Y. Sakamoto, M. Morimoto, M. Okada, and S. Komaki, "A wireless multimedia communication system using hierarchical modulation", IEICE Trans. Commun., vol. E81-B, no. 12, Dec. 1998.

[7] E. K. Wesel, "Wireless multimedia communications", Addison Wesely, 1998.

[8] B U Rindhe, D C Shah and S K Narayankhedkar, "OFDM and MC-CDMA for 4G Networks", International Journal of Computer Applications, 2011

[9] Shekhar Pundir, Vivek Agarwal, Brahma datta Tyagi, Rakesh K. Pandey and Santosh P. Singh, "study of methods to mitigate fading in mobile communication", international journal of engineering science and advanced technology, vol. 2, Issue-3, pp. 594 – 599, May-Jun 2012.

[10] Jigisha N. Patel and Upena D. Dalal, "A Comparative Performance Analysis of OFDM using MATLAB Simulation with M-PSK and M-QAM Mapping", International Conference on Computational Intelligence and Multimedia Applications, 2011.

[11] Jae-min Kwak, Yang-sun Lee, and Sung-eon Cho, "The Performance Evaluation of OFDM/HL-16QAM System for Optimizing Image Transmission Quality in Wireless Fading", International Conference Glasgow, UK, , Part V, May, 2006 .

[12] Sassan Ahmadi, LTE-Advanced A Practical Systems Approach to Understanding the 3GPP LTE Releases 10 and 11 Radio Access Technologies, First Edition, Academic Press, 2014

[13] Y. S. Cho, J. Kim, W. Y. Yang and C. G. Kang, MIMO-OFDM Wireless Communications with Matlab, John Wiley & Sons (Asia) Pte Ltd, 2010.

[14] Umer Ijaz Butt, A Study on the Tone-Reservation Technique for Peak-to-Average Power Ratio Reduction in OFDM Systems, DISSERTATION.COM, 2010.

[15] K. Fazel and S. Kaiser, Multi-Carrier and Spread Spectrum Systems from OFDM and MC-CDMA to LTE and WiMAX, Second Edition, A John Wiley and Sons, 2008.

[16] Yang Zhang, Qiang Ni and Yonghua Song, "Intelligent Genetic Algorithms for Next-Generation Broadband Multi-Carrier CDMA Wireless Networks", Doctor thesis, BruneI University, August 2008.

[17] L. Hanzo, L-L. Yang, E-L. Kuan and K. Yen, Single- and Multi-Carrier DS-CDMA: Multi-User Detection, Space-Time Spreading, Synchronisation, Networking and Standards, John Wiley & Sons, 2003.

[18] Lajos L. Hanzo and Thomas Keller, OFDM and MC-CDMA, First Edition, Wiley-IEEE Press, 2006.

[19] G. BRINDHA," performance analysis of MC-CDMA system using BPSK modulation", International Journal of Research in Engineering and Technology, Vol. 1, Issue 1, pp. 45-52, June 2013.

[20] John Proakis, Digital Communications, Fourth Edition, McGraw-Hill Science Engineering Math, 2006.

[21] M. Divya, "Bit Error Rate Performance of BPSK Modulation and OFDM-BPSK with Rayleigh Multipath Channel", International Journal of Engineering and Advanced Technology, Vol.2, Issue-4, April 2013.

[22] Mosa Ali Abu-Rgheff, Introduction to CDMA Wireless Communications, First Edition, Elsevier Ltd, 2007

[23] www.dsplog.com, July 2008, "derive-pdf-rayleigh-random-variable", December 2014.

[24] Andreas F. Molisch, Wireless Communications, Second Edition, John Wiley & Sons, Ltd, 2011

[25] Yongwan Park and Fumiyuki Adachi, Enhanced Radio Access Technologies for Next Generation Mobile Communication, Springer, 2007.