International Journal of Research in
Engineering & Technology (IJRET)
Vol. 1, Issue 1, June 2013, 45-52

PERFORMANCE ANALYSIS OF MC-CDMA SYSTEM USING BPSK MODULATION

G. BRINDHA

Assistant Professor, Lord Jegannath College of Engineering and Technology, Ramanathichanputhur, Tamil Nadu, India

ABSTRACT

Multi Carrier Code Division Multiple Access (MC-CDMA) is an attractive choice for high speed wireless communication as it avoids the problem of Inter Symbol Interference (ISI) and also exploits frequency diversity. In order to support multiple users with high speed data communications, the MC-CDMA technique is used to address these challenges. MC-CDMA experiences severe multipath fading which badly affects its performance. When transmission over fading channel multi-cell interference occurs and this degrades the performance of the system. This paper specially analyzes the BER performance under Rayleigh fading channel conditions of MC-CDMA in presence of AWGN (Additive White Gaussian Noise) using BPSK modulation for different number of subcarrier, different number of users using MATLAB program, and finally the paper also presents a comparison between simulated results, which shows the reduction in BER performance.

KEYWORDS: CDMA, MC-CDMA, ISI, AWGN, BER, Rayleigh Fading Channel

INTRODUCTION

Broadband wireless access for evolving mobile internet and multimedia services are driving a surge of research on future wireless communication systems, which have to be highly spectral efficient in order to support multi-user access and high data rates. Therefore, MC-CDMA formed by combining orthogonal frequency division multiplexing (OFDM) with code division multiple accesses (CDMA) became significant research topics [1-3]. The former is well suited for high data rate applications in frequency selective fading channels and the lat7er is a multiplexing technique where number of users is simultaneously available to access a channel. Data transmission involves spreading operations which are carried out by short channelisation code and long scrambling code. Short channelization code helps in separating the signals of different users present within the cell and long scrambling code mitigates the effects of interference produced by users belonging to other cells. However, the scrambling codes are generally not orthogonalised among cells. Therefore, since the signals from other cells cannot be orthogonalised to the signals of its own cell, multi-cell interference exists. In high data rate transmission system over frequency selective fading channel, multi-cell interference results in degradation of bit-error rate (BER) and this characteristic affects the performance of MC-CDMA systems.

MC-CDMA is one representative of the MC technique. It has emerged as another feasible option for forward-looking MC communications systems by exploiting the flexibility and potential offered by the combination of OFDM and CDMA[4]. With a surging increase in demand for personal wireless radio communications within the past decade, there is a growing need for technological innovations to satisfy theses demands. Future technology must be able to allow users to efficiently share common resources, whether it involves the frequency spectrum, computing facilities, databases, or storage facilities[l].The multicarrier(MC) technique has grown an important alternative for wireless indoor communications.

MC-CDMA SYSTEM

Multi-Carrier Code Division Multiple Access (**MC-CDMA**) is a multiple access scheme used in OFDM-based telecommunication systems, allowing the system to support multiple users at the same time.MC-CDMA spreads each user symbol in the frequency domain[5]. That is, each user symbol is carried over multiple parallel subcarriers, but it is phase shifted (typically 0 or 180 degrees) according to a code value. The code values differ per subcarrier and per user. The receiver combines all subcarrier signals, by weighing these to compensate varying signal strengths and undo the code shift. The receiver can separate signals of different users, because these have different (e.g. orthogonal) code values.Since each data symbol occupies a much wider bandwidth (in hertz) than the data rate (in bit/s), a signal-to-noise-plus-interference ratio (if defined as signal power divided by total noise plus interference power in the entire transmission band) of less than 0 dB is feasible.

There are many ways to describe the MC-CDMA, but generally it is described as DS-CDMA again modulated by an OFDM carrier, the number of sub-carriers depends upon the length of spreading code used with DS-CDMA[6]. One major difference between MC-CDMA and OFDM is the subcarriers in MC-CDMA at any instant transmits the one symbol but in OFDM each sub carrier transmit separate symbol, the efficiency of MC-CDMA is hidden in orthogonal sub carrier by which the overlapping spectrum of successive subcarriers can be separated other advantage comes from a wideband coverage of carriers and slower transmission time or larger transmission duration for each bit.MC-CDMA technique has some unique advantages over its root techniques (OFDM, DS-CDMA) Compared to Direct Sequence (DS) CDMA.

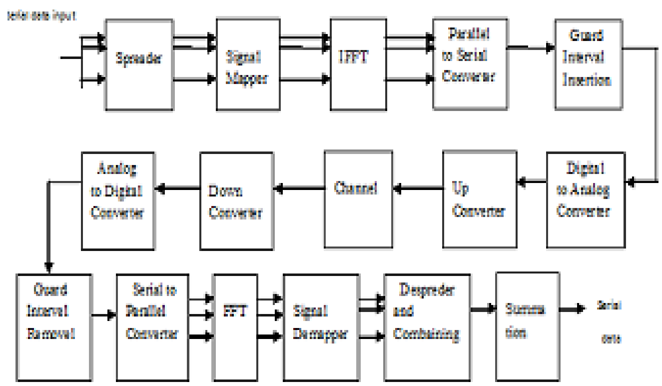

Figure 1: MC-CDMA System

Multicarrier CDMA is likely to be the transmission method of future mobiles due to its bandwidth efficiency and inherent diversity over fading channel. However the multi-carrier signals show highly varying envelope power waveforms, which hinder the popular employment of multicarrier CDMA. Our research focus is to study this phenomenon and to provide some practical solutions for it. Since the introduction of OFDM, there are many researches that have been focus to fully exploit the benefits of OFDM either in improving the data rate, the capacity or achieve better spectrum efficiency with the technique. Any researchers have proposed the merger of OFDM [2] [3] and CDMA systems to achieve better spectrum efficiency and also increase the system capacity. This section takes a look at a scheme widely proposed by researchers in this field called the OFDM-CDMA system. This system is also known as the- MC CDMA (Multi -carrier CDMA) system. MCCDMA system achieves comparable performance of DS-CDMA, however, the benefits of the M-CCDMA system lies within its flexibility and the relatively simple receiver design.

MC-CDMA transmitter is similar to OFDM transmitter but for small difference. In OFDM different symbols are transmitted by subcarriers but in MC-CDMA same symbol is transmitted by different subcarriers. The explanation of the above concept is clearly shown in figure1. The input high data rate symbols are converted to parallel streams. Then each parallel stream is spread using spreading codes like Walsh, Hadamard etc. From there, the transmitter structure follows the ordinary OFDM system. The OFDM system associated with the CDMA system converts the symbols to time domain samples by Inverse Fast Fourier Transform (IFFT) and assigns a subcarrier for each symbol. Then the subcarriers are multiplexed to form as a serial stream. Before transmission the serial stream is converted to blocks and each block is separated by a guard frame. The guard frame is usually a zero symbols or known symbols[7]. In OFDM the guard symbols are cyclic prefix of the block where a part of the symbols belonging to a block is appended which has various advantages. The receiver structure moves the known/zero symbols which acted as guard interval. The serial stream is converted to parallel stream which in turn is send to Fast Fourier Transform (FFT) block for conversion of time domain samples to frequency domain samples. The de-spreading and combining operation is preceded by frequency domain equalizer. The conjugate of the frequency response of the channel estimated is multiplied with the frequency domain samples of the FFT block.

CHANNEL MODEL

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.

AWGN Channel Model

Additive White Gaussian Noise channel model as the name indicate Gaussian noise get 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. Additive white Gaussian noise (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[8]. The model does not account for fading, frequency selectivity, interference etc. 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.

SYSTEM MODEL

In this section, we describe the transmitter and receiver model of MCCDMA system. Here, symbols are modulated on many subcarriers to introduce frequency diversity instead of using only one carrier like in CDMA. Thus, MC-CDMA is robust against deep frequency selective fading compared to DS-CDMA [10]. Each user data is first spread using a given high rate spreading code in the frequency domain. A fraction of the symbol corresponding to a chip of the spreading code is transmitted through different subcarriers [8].

The block diagram of an MC-CDMA transmitter is shown in Figure 2 and receiver for the downlink of a mobile radio system is shown in Figure 3. After channel coding, the coded bits are subdivided into chips by multiplication with user specific spreading codes. To minimize the interference between users, orthogonal Walsh-Hadamard codes are used for spreading. A key feature of an MC-CDMA system is that all chips assigned to a single code bit are transmitted in parallel on narrowband subcarriers by applying OFDM. Thus, each chip is affected by frequency nonselective fading (flat fading) on the channel. To increase the diversity gain in the mobile radio channel, a frequency/time interleaver scrambles the chips of the coded bits before OFDM. A guard interval is added between adjacent OFDM symbols to avoid intersymbol interference. Thus, a complex receiver can be avoided. Splitting the users into independent user groups with reduced spreading code length L=8 has been proposed [9] to enable the application of Maximum Likelihood Sequence Estimation (MLSE) with low complexity for joint detection of the user data. The diversity gain achievable with synchronous MC-CDMA in mobile radio channels has been investigated for uncoded transmission. Different GSM channel models have been considered in the investigations.

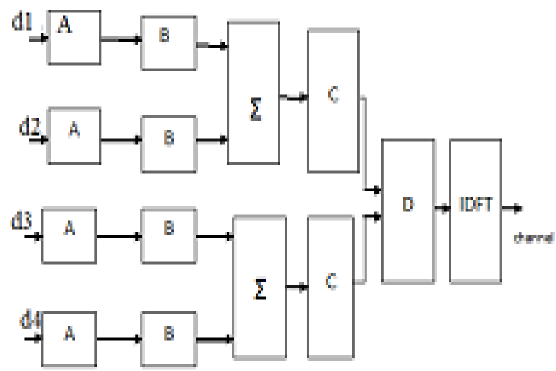

Figure 2: MC-CDMA Transmitter

A-Channel Encoder, B-Spreader, C-Serial-Parallel Converter, D-Interleaver

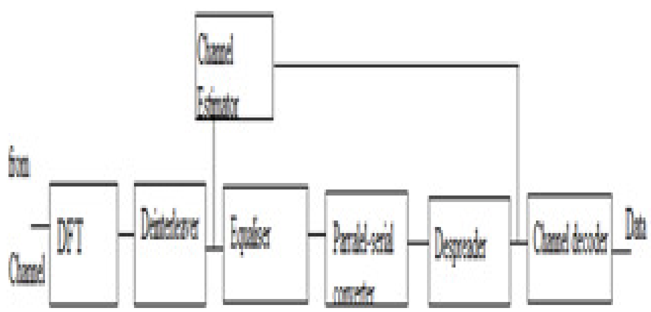

Figure 3: MC-CDMA Receiver

Finally, the signal is converted back to serial and modulated to send through the communication channel. At the receiver, data are converted to parallel streams and each block with spread signals is decomposed by Fast Fourier Transform (FFT) into subcarriers and transformed into frequency domain for despreading to recover original data. The equation models the MC-CDMA transmitter for Binary Phase Shift Keying (BPSK). Dividing a single carrier signal to multiple subcarrier signals means that data are actually divided in to several parallel data streams or channels, one for each subcarrier[11]. Each subcarrier signal is then modulated with low symbol rate such that the total data rate of these subcarrier signals will be equal to conventional single carrier data rate. The main idea behind this technique is that a signal with long symbol duration time is less effected by multipath fading as compare to signal with short symbol duration, like in CDMA [2].

SIMULATION RESULTS

Bit error rate (BER) of a communication system is defined as the ratio of number of error bits and total number of bits transmitted during a specific period. It is the likelihood that a single error bit will occur within received bits, independent of rate of transmission[12]. There are many ways of reducing BER. In our case, we have considered the most commonly used channel: the Additive White Gaussian Noise (AWGN) channel where the noise gets spread over the whole spectrum of frequencies. The simulation parameters are shown in the table1.

Table 1

Channel	AWGN, Rayleigh
Modulation	BPSK
Spreading	Walsh hadamard Code
No of subscribers	1024
FFT size	64
Symbol Duration	64µsec
Guard Interval	16 µsec
Effective symbol Duration	80 µsec

BER has been measured by comparing the transmitted signal with the received signal and computing the error count over the total number of bits[12]. For any given BPSK modulation, the BER is normally expressed in terms of signal to noise ratio (SNR).To plot BER vs. SNR graph in AWGN channel, a predefine function we have used in MATLAB programming. Here, awgn function is used to define a AWGN channel. Then gradually the values of SNR increases in AWGN channel and calculate the BER value. Using these values the graph was plotted.Figure4 shows the simulated graph between BER and SNR for BPSK modulation scheme.

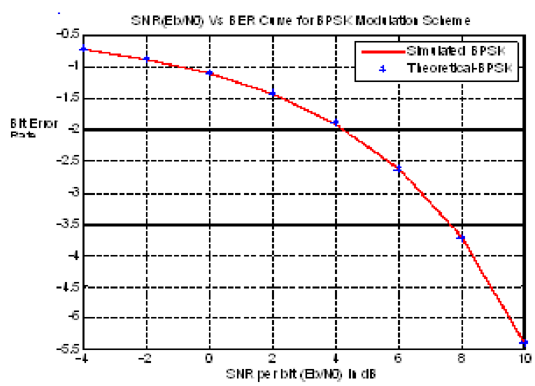

Figure 4: BER Curve for BPSK Scheme

Next, we generate random the BPSK modulated symbols +1's and -l's, then we pass them through the AWGN channel after that we demodulate the received symbol based on the location in the constellation, then we count the number of errors finally repeat the same for multiple Eb/No values. Figure5 shows the BER curve using BPSK modulation on AWGN channel.

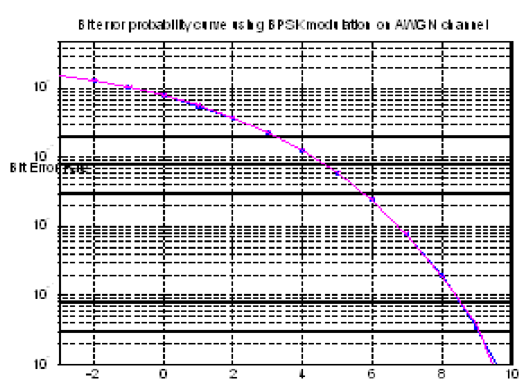

Figure 5: BER Curve on AWGN Channel

Then the BER is simulated using Rayleigh channel and the procedure for MATLAB simulation of a BPSK transmission and reception in Rayleigh channel is as follows:- First we generate random binary sequence of + l's and l's, then multiply the symbols with the channel and then add Rayleigh. At the receiver, we equalize (divide) the received symbols with the known channel & perform hard decision decoding and count the bit errors. Finally we repeat for multiple values of Eb/No. Figure 6 shows the simulation plot of BER on Rayleigh Channel.

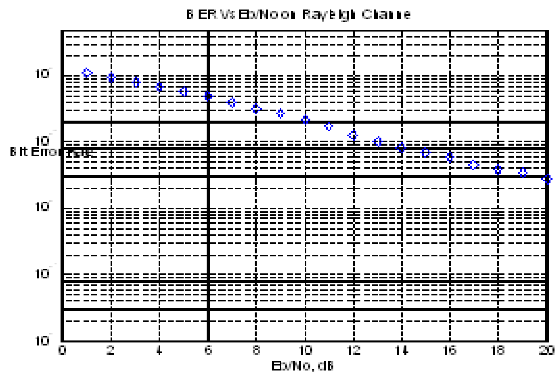

Figure 6: BER Curve on Rayleigh Channel

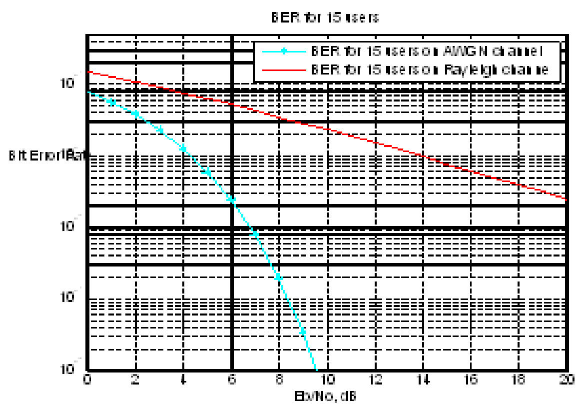

Figure 7: BER for 15 Users

This shows that the BER rises as the SNR of the channel decreases and vice versa. For 15 users when the SNR less than 10dB the BER becomes significant. From the Figure 7, it is seen that BER is unacceptable for 20 and 30 users for any SNR. Here 20 and 30 users become unusable because it provides high multiple access interference.MC-CDMA result for 30 users is clearly worse than MC-CDMA result for 10 users under multipath delay spread condition. For delay spread, high BER occur because the PN sequence becomes uncorrelated.

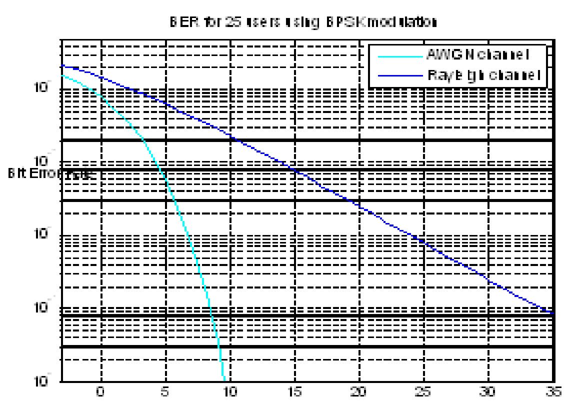

Figure 8: BER for 25 Users Using BPSK Modulation

Computer simulations are done to simulate SNR vs. BER performance of MC-CDMA for different channel noise conditions, different number of subcarriers and to analyze the effect of number of users in BER. To make the results more useful, the results are generated for different number of users and for different number of subcarriers.Figure8.shows the simulation of BER Vs SNR for 25 users. Throughout the simulation, the information symbol is BPSK modulated at the transmitters and detected by using the maximum likelihood detection.

CONCLUSIONS

In this paper we try to present the performance of MCCDMA in AWGN channel and Rayleigh channel Using BPSK modulation technique. As from the graph it is evident that as Eb/No increases the BER decreases.BER vs. SNR graphs for single user and multi users in both AWGN and Rayleigh Fading channel plotted and analysed successfully using MATLAB programming. Here BER for different number of users are plotted both for AWGN and Rayleigh channel and their performance is studied.

FUTURE SCOPE

This study leaves wide scope for future investigations. It can be extended to analysis of interference in MC-CDMA due to fading channel and how to cancel that interference. The same system can be investigated using different modulation techniques.

MC-CDMA technology is more useful for 3G and 4G mobile generations. There is a very wide scope for future scholars to explore this area of research in the field of MC-CDMA. Many other problems like capacity, high data speed rate channel estimation and low interference are require further investigation.

REFERENCES

1. PERFORMANCE ANALYSIS OF MCCDMA SYSTEM IN RAYLEIGH CHANNEL AND AWGN CHANNEL USING BPSK MODULATION TECHNIQUE, Mr.V.Satish, Mr.K.Suresh, Ms.B.Swati, International Journal Of Engineering Research And Applications (IJERA) ISSN: 2248-9622 Www.Ijera.Com Vol. 1, Issue 4, Pp. 2025-2029
2. Performance Analysis Of MC-CDMA For Rayleigh Fading Channel, Vikasgupta, Rubytiwari,TIT Bhopal Computer Engineering And Intelligent Systems,ISSN2222-1719 (Paper) ISSN 2222-2863 Vol2, No.5, 2011
3. PERFORMANCE IMPROVEMENT OF MC-CDMA SYSTEM THROUGH DSTBC SITE DIVERSITY, N.Kumaratharan,P.Dananjayan,M.Padmavathy,JournalOf Theoretical And Applied Information Technology.
4. Simulation Based Performance Analysis Of MCCDMA And CDMA Over Rayleigh Fading Channel, Mohammedfaisal,Jiauddin,Iqbalhasanhaider,(IJIDCS) International Journal On Internet And Distributed Computing Systems. Vol: 2 No: 1, 2012
5. EFFICIENT RESOURCE ALLOCATION IN MC-CDMA CELLULAR WIRELESS NETWORKS TO SUPPORT MULTIMEDIA TRAFFIC, DhananjayKumar, C.Chellappan,JournalOf Theoretical And Applied Information Technology.
6. International Journal Of Distributed And Parallel Systems (IJDPS) Vol.2, No.6, November 2011,DOI: 10.5121/Ijdps.2011.2629 347,Channel Estimation For MIMO MC-CDMA Systems, K.Sureshkumar, R.Rajalakshmi, A.Vetrikanimozhi.

7. International Journal Of Research And Reviews In Computer Science (IJRRCS) Vol. 2, No. 2, April 2011,Performance Analysis Of Wavelet Based MC-CDMA System With Implementation Of Various Antenna Diversity Schemes, Md. Matiqul Islam, M. Hasnatkabir And Sk. Enayetullah, UniversityOfRajshahi.
8. Performance Analysis AndSimulation Result Of MC-CDMA For AWGN Channel And Raleigh Based On SNR/BER,Mr.Vikasgupta, Ms.Ruby Tiwari.
9. BER ENHANCEMENT OF MIMO-CDMA BASED ON SPACE-TIME BLOCK CODES P. Sreesudha, M. Vijayalakshmi,Dept. Of ECE, GNITS, Hyderabad, India.
10. European Journal Of Scientific Research ISSN 1450-216X Vol.38 No.4 (2009), Pp 590-595Performance Analysis Of Multi-Carrier Code Division Multipleaccess System Under Clipping Noise, S. SivanessKumar, R.Sukanesh.
11. Evaluation OfCDMA System Performance In Wireless Telecommunication ,Md. Younus Ali, M. M. Ashiqurrahman, S.M. Shamsulalam, *And* Rajiv Kumar Mistry, IJCIT, ISSN 2078-5828 (PRINT), ISSN 2218-5224 (ONLINE), VOLUME 02, ISSUE 02, MANUSCRIPT CODE: 1200107
12. Performance Of Adaptive MC-CDMA Detectors Inrapidly Fading Rayleigh Channels, Dimitris N. Kalofonos*, Member, IEEE*, Milicastojanovic*, Member, IEEE*, And John G. Proakis*, Life Fellow, IEEE,*IEEE TRANSACTIONS ON WIRELESS COMMUNICATIONS, VOL. 2, NO. 2, MARCH 2003.