Analysis and comparison of BER in cellular communication using Multi carrier-CDMA Technology

J.kameswararao (M.Tech).,SSCE,SRIKAKULAM 8096712159,sun.kameswararao@gmail.com
T.Manikyala Rao Assoc prof.ECE.,SSCE,SRIKAKULAM manik.me.au@gmail.com
D. Chiranjevulu Asst prof.ECE.,SSCE,SRIKAKULAM chiru.divvala @gmail.com

Abstract- In twenty first century mobile cellular communication is playing a vital role in our day to day life. The vast usage of mobile services has given birth to various security issues and errors in data communication. To sort out these issues it is essential to choose an effective coding technique to improve the Bit Error Rate and to provide timely security in 4G technology by performing various simulations. The main objective of this paper is to develop better codes to get one of the best BER Performances under the above mentioned conditions by performing various simulations. The performance of MC-CDM is to be evaluated using the best codes in Additive White Gaussian Noise (AWGN) and Rayleigh fading channel. The performance of MC-CDMA is evaluated by Computer simulation and control the bit error rate (BER) as a function of bit energy to noise density ratio (Eb/No).

Keywords- Multicarrier, BER, CDMA, Multipath Fading, Coding Techniques, Channel Noises.

I. INTRODUCTION

Future wireless communication systems must be able to accommodate a large number of users and at same time to provide the high data rates at the required quality of service. MC-CDMA is taking the advantage of two advanced technological concepts of wireless communications such as the code division multiple access (CDMA) and orthogonal frequency division multiplex(OFDM), especially in the multiple access capability, high spectral efficiency, robustness in the case of frequency selective channels, simple one-tap equalization, narrow-band interference rejection and high flexibility of the MC-CDMA. The outlined potential properties of the MC-CDMA represent the fundamental reasons, why MC-CDMA has been receiving a great attention over the last few days and has been considered a promising candidate for the future advanced wireless communication systems.

One of the major requirements are posed to the MC-CDMA is to reach the date rate at the acceptable complexity and acceptable bit error rate (BER) for the defined number of the active users. Mostly the Global System for Mobile telecommunications (GSM) technology is being applied to fixed wireless phone systems in rural areas or Australia. However, GSM uses time division multiple access (TDMA), it has a high symbol rate to prevent problems with multi path causing inter-symbol interference.

Multiple techniques are consideration for the feature generation of digital mobile systems, with the aim of improving cell capacity, multi path immunity, and flexibility. These include CDMA as well as OFDM. Both techniques could be used for rural areas to providing a fixed wireless system. Every technique as different properties, specific applications making it more suited. OFDM is currently being used in more new radio broadcast systems and the proposal for High Definition Digital Television (HDTV) and Digital Audio Broadcasting (DAB). However, small research has been done into the use of CDMA and OFDM as a transmitter and receiver for cellular mobile systems.

II. MULTIPLE ACCESS TECHNIQUES

Multiple access schemes are used to allow many simultaneous users to use the same fixed bandwidth radio spectrum. In any radio system, the bandwidth allocated is always limited. For mobile phone systems the total bandwidth is typically in MHz i.e., 50MHz, which is split in half to provide the forward and reverse links of the system. Sharing of the spectrum is required in order increase the user capacity of any wireless network [2]. TDMA, FDMA and CDMA are the three major methods of providing the available bandwidth in to multiple users in wireless system. However, an understanding of these methods we required for understanding of extensions to these methods.

A. Time Division Multiple Access:

Time Division Multiple Access (TDMA) divides the available spectrum into multiple slots divided with time, by giving a time slot in transmit or receive to each user. Figure 3 shows how the time slots are provided to users in a round robin fashion, with each user being allotted one time slot per frame.

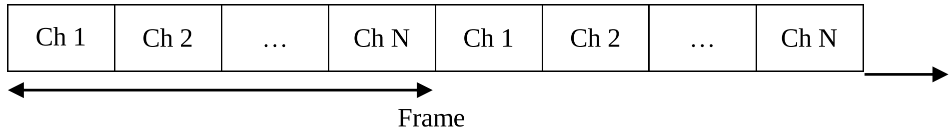


Fig.1.TDMA scheme where each user is allocated a small time slot

TDMA systems transmit data in a buffer method, so the transmission of each channel is non-continuous. The input data to be transmitted is buffered over the past frame and burst transmitted at a higher rate during the time slot for the channel shown fig.1.

ISSN 2091-2730

Analog signals cannot send directly in TDMA because it required buffering, thus are only used for transmitting digital data. TDMA can suffer from multi path effects, as the transmission rate is generally very high. This leads the multi path signals causing inter-symbol interference.

This is used to reduce the effect of delay spread on the transmission. Several users can transmit of the one channel. This transmission technique is used by most second generation mobile phone systems.

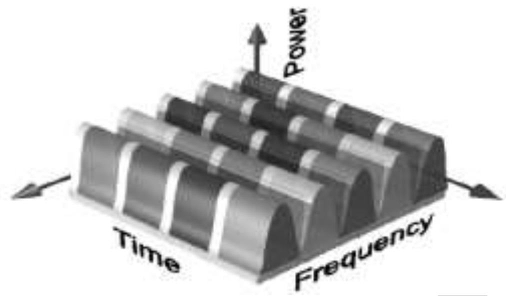


Fig.2. TDMA / FDMA hybrid, showing that the bandwidth is split Frequency Channels and time slots

B. Frequency Division Multiple Access:

The available total bandwidth is subdivided into a number of narrower band channels in Frequency Division Multiple Access (FDMA) and allocated a unique frequency band in transmit and receive to each user. No other user can use the same frequency band during a call. Each user is allocated a forward link channel (from the base station to the mobile) and a reverse channel (mobile to the base station), this are a single way link.

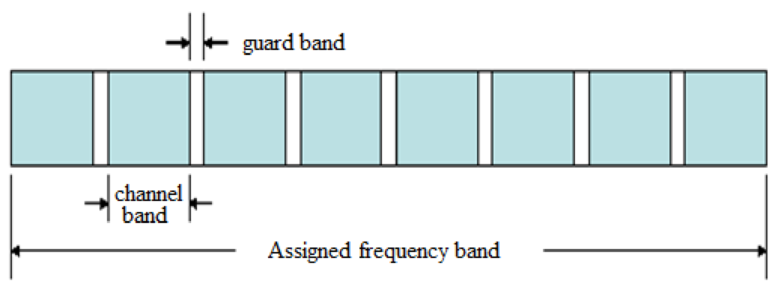


Fig.3. FDMA spectrum, where the available bandwidth is subdivided into narrower band channels

The bandwidths of FDMA channels are very low approximately 30 kHz and each channel only supports only one user. FDMA is used is used as part of most multi-channel systems [3]. Figure shows the allocation of the available bandwidth into several Channels explained in Fig.3.

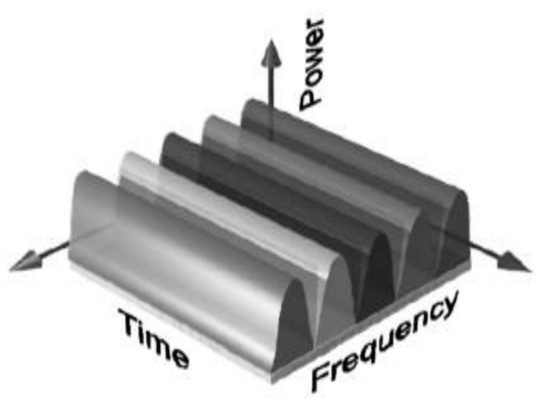


Fig.4. FDMA showing that the each narrow band channel is allocated to a single user

C. CDMA:

CDMA technology was originally developed by the military during World War II researches were spurred into communicating that can be secure and work in the presence of jamming [4]. A CDMA system is a multi-user spread spectrum system that eliminates the frequency reuse problem in cellular systems shown in Fig.5.

Unlike TDMA and FDMA systems, where user data never overlap in either the frequency domains or the time domains, respectively, a CDMA system allows transmissions at the same time while using the same frequency. For example, in the first widespread commercial CDMA system, the mechanism separating the users in a CDMA system consists of assigning a unique code that modulates the signal from the each user. The unique codes in a CDMA are equal to the number of active users. The code modulating the user's signal is also called a spreading code, spreading sequence, or chip sequence.

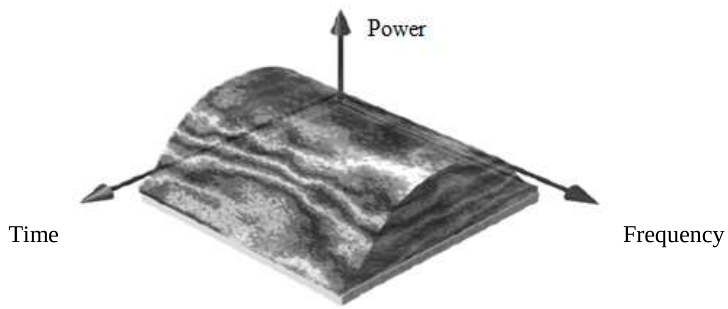


Fig.5. CDMA View

D. OFDMA:

The multicarrier transmission technique is OFDM, which divides the available spectrum into many carriers like Fig.6, each one being modulated by a low rate data stream. It has high popularity because of its capability to transmit effective data rate in a mobile environment, which makes a highly hostile radio channel. This method has been used in the implementation of (High Performance LAN (HIPERLAN/2), IEEE standard 802.16 and 802.11a.

OFDM is similar to FDMA the multiple user access is achieved by subdividing the total bandwidth into number of channels that are provided to users. OFDM more efficiently uses the total spectrum with closer spacing the channels together [6]. This is achieved by all the carriers orthogonal to one another by spacing them at integer multiples of the frequency. When the powers of the other subcarriers are null then the peak power of one subcarrier occurs, thereby countering any effect of interference.

The OFDM signal can be to represented as to generate OFDM successfully all the carriers must be controlled to maintain orthogonality of the carriers. This particulate reason, OFDM is generated by firstly choosing spectrum required, based on the input data, and modulation scheme used. Each carrier to be individually produced is assigned data to transmit.

The required phase and amplitude of the particular carrier is then calculated based on the modulation scheme (typically differential BPSK, QPSK, or QAM). The required spectrum is converted back to its actual time domain signal using an Inverse Fourier Transform. Present in most applications, an Inverse Fast Fourier Transform (IFFT) is also used. The IFFT performs transformation most efficiently, and provides a simple way of the carrier signals produced orthogonal.

OFDM Carriers Spectrum

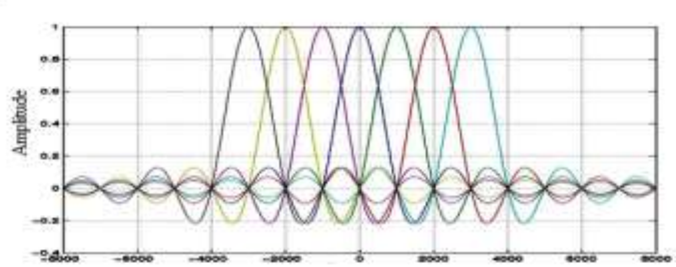


Fig.6. Model graph of OFDMA

The Fast Fourier Transform (FFT) is transforms a cyclic time domain signal into its equivalent frequency spectrum. This is done by finding its equivalent waveform, and it generated by a sum of orthogonal sinusoidal components. The amplitude and phase of the sinusoidal there components represent the frequency spectrum of the time domain signal. The IFFT performs the back process, converting a spectrum (phase and amplitude of each component) into a time domain signal. Number of complex data points converts by IFFT, of length that is a power of 2, into the time domain signal of the same number of points. For an FFT or IFFT each data point in frequency spectrum is used so it is called a bin.

E. OFDMA Transmitter and Receiver:

For the OFDM signal the orthogonal carriers required and it can be easily generated by setting the amplitude and phase of each frequency bin, then performing the IFFT. Each bin of an IFFT corresponds to the phase and amplitude of a set of orthogonal sinusoids, the reverse process guarantees that the carriers generated are orthogonal. OFDM is almost similar to FDMA in that the multiple user access is achieved by subdividing the available total bandwidth into multiple channels that are then allocated to users. OFDM uses the spectrum more efficiently by spacing the channels very closer together. This is achieved by to make all the carriers orthogonal to one to other by spacing them at integer multiples of the symbol frequency

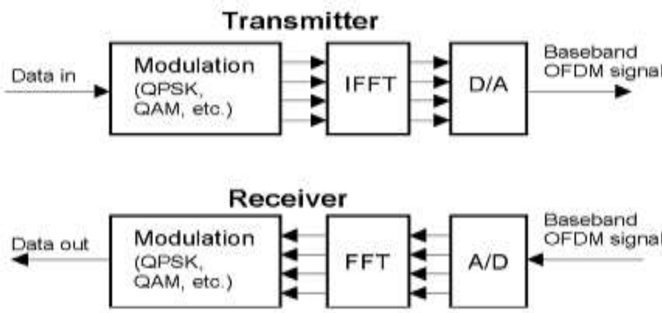
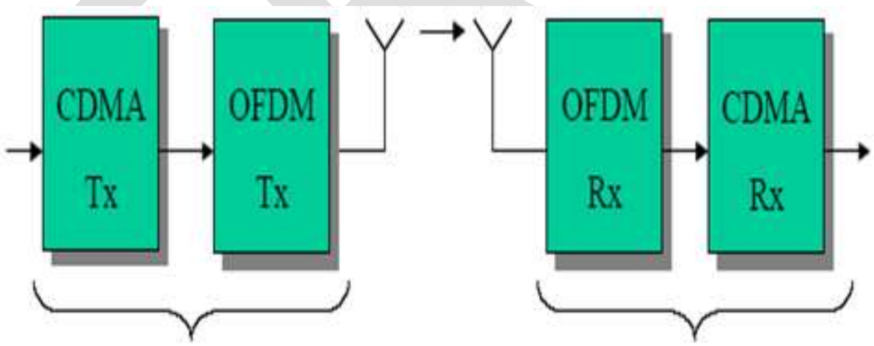


Fig.7. OFDMA Transmitter and Receiver

Thus, the peak power of one subcarrier occurs when the power of the other subcarriers are null, thereby countering any effect of interference. The Inter Symbol Interference (ISI) problem arising in OFDM can be removed by introducing certain guard bands between the subcarriers. This can be completely eliminated if the symbol is cyclically extended, by repeating the first part of the block at the end. The receiver can then operate on the part of the signal beyond the ISI with the only side effect a phase shift on each sub-carrier.

III. ADVANCED METHOD MC-CDMA

The MC-CDMA system has been considered as one of the possible candidates for the next generation of wireless communications. The MC-CDMA system divides the available bandwidth into a large number of narrow subchannels and spreads each data symbol in the frequency domain by transmitting all the chips of a spread symbol at the same time but in different orthogonal subchannels. One of the properties of multicarrier transmission is that the channel gain of each subchannel is different from the other. The inner product of different spreading codes will no longer be zero since the MC-CDMA systems spread transmitted symbols in a non-flat fading channel [7].



MC-CDMA Tx MC-CDMA Rx

Fig.8. MC-CDMA block diagram

The internal blocks of MC-CDMA are transmitter and receiver.MC-CDMA transmitter section has CDMA, OFDM transmitters same as MC-CDMA receiver section has CDMA, OFDM receivers. in transmitter part encoder followed by mapper (QPSK or BPSK). The block of interleaving labelled in the presented scheme, multilevel sequence of complex numbers in M-array or BPSK modulation formats. The spread symbols are modulated by the multi-carrier modulation and it implemented by the Inverse Fast Fourier transformation operation (IFFT). After parallel-to-serial (P/S) conversion, the cyclic prefix (CP) is inserted in order to mitigate the inter-symbol interference (ISI) caused by the frequency-selective fading channel and The receiver consists of the serial-to-parallel converter (S/P), blocks of the Fast Fourier Transformation (FFT), channel equalization (EQ) using zero forcing method, CP removal Matched filters (MF), transformation, decision device, inverse block and finally decoding block.

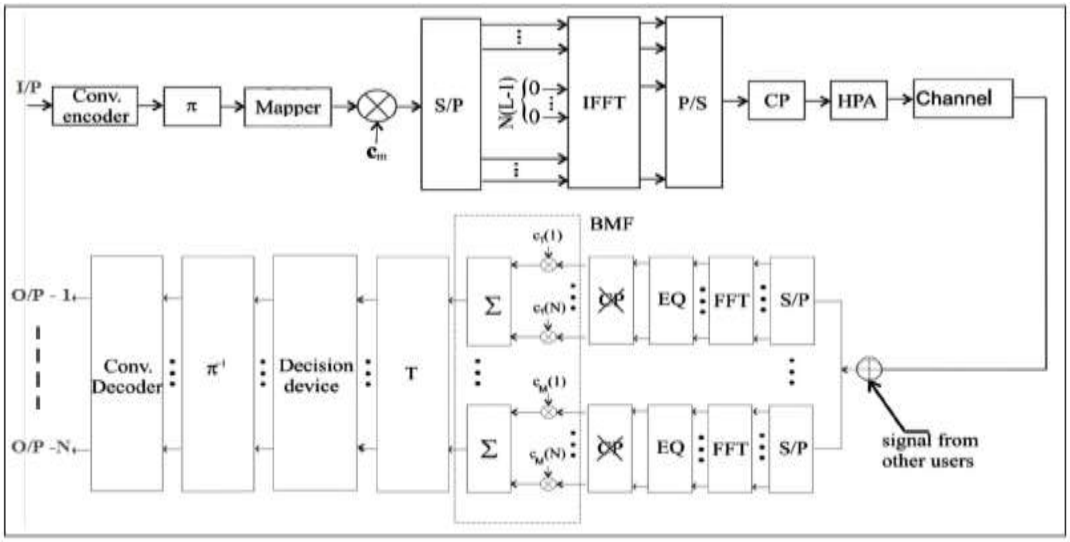


Fig.9. MC-CDMA internal block diagram

IV. NOISE IN COMMUNICATION CHANNEL

Within any communication channel, there is always noise present due to other surrounding radio signals. These noise can be white (colorless) or colored noise, and with interact differently with the transmitted user signal, for instance, the interaction can be additive, multiplicative or complex. In communication systems, the transmitting signal is much Vulnerable to noise especially with in the communication channel. Mostly in wireless channel considered AWGN and Rayleigh noise.

A. White Noise*:*

White noise is a type of noise that is often exists in communication channels. Compare to any other types of noise it is different, hence the fact that its Power Spectral Density (PSD) is independent of the operating frequency the word "White" is used in the sense that white Light contains all other visible light frequencies in the band of electromagnetic radiation.

B. Rayleigh noise:

The Rayleigh fading channel is mostly applied in case when there is no LOS between R_X and $T_{X.}$ Mostly channel also adds AWGN noise to the signal samples after it suffers from Rayleigh fading. The Rayleigh probability density function is given by

Received signal Y = hX + n,

Where X i s T_x signal, h is Rayleigh fading response and n is AWGN.

$$f(x) = \begin{cases} \frac{x}{\sigma^2} e^{-\frac{x^2}{2\sigma^2}} & x \geq 0 \\ 0 & x < 0 \end{cases} \quad (1)$$

Where $\boldsymbol{\sigma}^2$ is known as the fading envelope of the Rayleigh distribution, in theoretical BER for BPSK Rayleigh fading

$$P_b = 1/2 \ \mathrm{erfc}\sqrt{(E_b/N_o)} \quad (2)$$

In theoretical BER for BPSK Rayleigh fading with AWGN channel

$$P_b = 1/2 \ (1-\sqrt{((E_b/N_o)/1+(E_b/N_o))}) \quad (3)$$

Here we using spreading codes before IFFF process so, the spreading codes are Long PN sequence, Walsh coding and Gold code.

V. CODE GENERATORS:

A. Long PN sequence:

A Long PN sequence is uniquely assigned to each user and it is a periodic long code with Period 2^42 -1. There are two reasons for using the long PN sequence.

1. Channelization the base station separates forward channel traffic by applying different Sequences to different subscribers
2. Privacy Each user uses different long codes, and due to the pseudorandom nature of the Codes, due to they are difficult to decode as different sequences are orthogonal to each other.

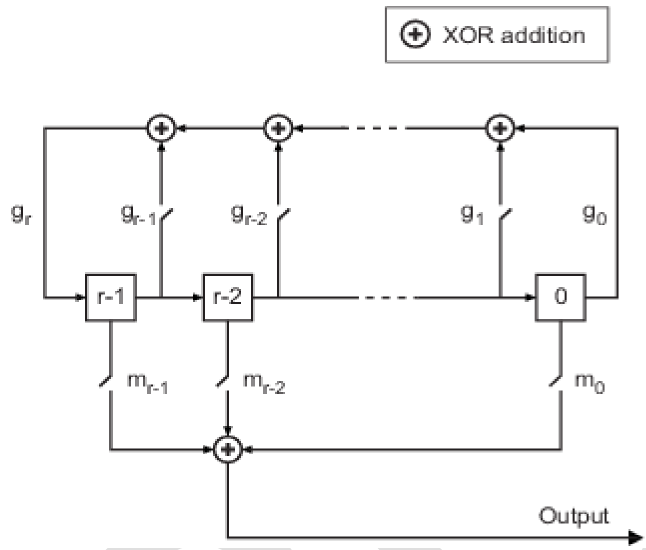


Fig.10. Generating PN sequences

Here are two ways for generating the long PN sequence. First technique uses the Electronic Serial Number (ESN) of the subscriber to generate the long PN sequence and is therefore publicly known if the ESN is known. Second technique generates the long PN sequence Using keys that are known only to the base station and subscriber unit, providing a level of Privacy and preventing simple de-spreading In is-95,it is derived from an M-sequence with m =42 (shift register length). The greater polynomials are a Long Code Mask for generating long PN sequences is illustrated in Fig.10.

B. Orthogonal hadamard code:

Walsh coding is also called as Hadamard code. Walsh coding and it performed after data scrambling in the transmitter. Each data symbol coming Out of the scrambler is replaced by 64 sequence of Walsh chip. Each 64 Walsh chip sequence corresponds to a row of the 64 by 64 Walsh matrix (also called a Handmaid matrix).The Walsh matrix contain one row of all zeros, and the remaining Rows each have an equal number of ones and zeros and Figure3.5shows how a Walsh matrix is generated.

$$\begin{bmatrix} H & H \\ H & -H \end{bmatrix}$$

$H_1 = [1]$; And

$$H_2 = \begin{bmatrix} 1 & 1 \\ 1 & -1 \end{bmatrix},$$

$$H_{2^K} = \begin{bmatrix} H_{2^{K-1}} & H_{2^{K-1}} \\ H_{2^{K-1}} & -H_{2^{K-1}} \end{bmatrix} = H_2 \otimes H_{2^{K-1}}$$

Hadamard Matrix formation

Each subscriber is assigned a different row of 64 Walsh chips, depending on the channel Number which it is using, and each subscriber occupies a different channel. For example, if a Subscriber uses 23rd channel, each symbol of the subscriber's scrambled data symbol stream is processed using the 64 Walsh chips of the 23 row of the Walsh matrix. The symbol is simply replaced by the

23rd row Walsh chips when the scrambled data symbol is a 0. On the other hand if the data symbol is a1, the symbol is replaced by the bit-inverted version of the 23 Row Walsh chips. As a result, Walsh coding increases the data rate from 19.2ksps to 1.2288Msps.

C. Gold code*:* The Gold Sequence Generator block uses two PN Sequence Generator blocks to generate the preferred pair of sequences, after those XORs to produce the output sequence as shown in Fig.11.

The Gold Sequence Generator block generates a Gold sequence. It forms a large class of sequences that have good periodic cross-correlation properties. The Gold sequences are defined using a specified pair of sequences *u* and *v*, of period $N = 2^n - 1$, called a *preferred pair*, and defined in Preferred Pairs of Sequences below.

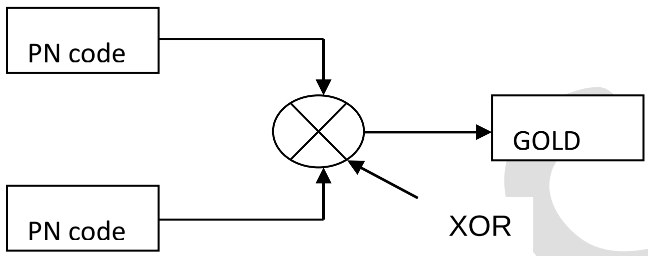


Fig.11. Gold code

The set G(u, v) of Gold sequences is defined. Where T represents the operator that shifts vectors cyclically to the left by one place, and represents addition modulo 2. Note that G(u,v) contains N + 2 sequences of period N. It is Generator block outputs one of these sequences according to the block's parameters. Gold sequences have the property that the cross correlation between any two, or in between shifted versions of them.

VI. SIMULATION RESULTS

The performance of MC-CDMA over AWGN channel using both orthogonal Hadamard as well as random codes can be seen in Fig. respectively. We can see that the MC-CDMA performance with orthogonal Hadamard codes does not degrade as the number of user increases, and it degrades with number of users when random codes are used. This is because of cross correlation between random codes increases with the number of users. We can expect when random codes are used over Rayleigh fading channel and AWGN channel, the performance of MC-CDMA will degrade more significantly because cross correlation between random codes will be affected by Rayleigh fading channel and AWGN channel

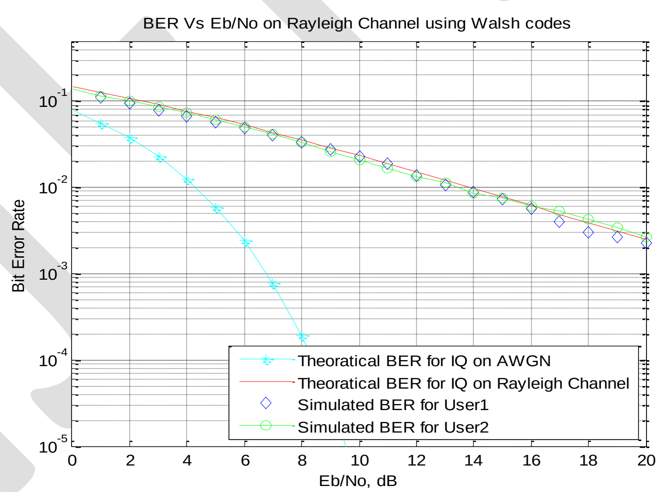


Fig.12.BER Vs Eb/No using Walsh code.

In Fig.12 specifies BER of detected user's with Walsh code.

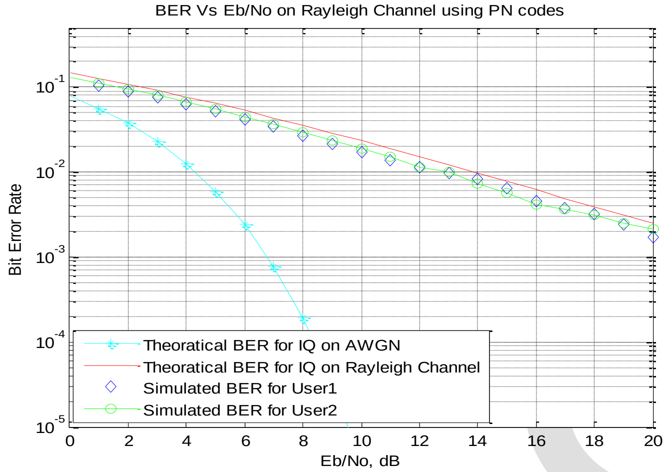


Fig.13.BER Vs Eb/No using PN code.

In Fig.13 specifies BER of detected user's with PN code.

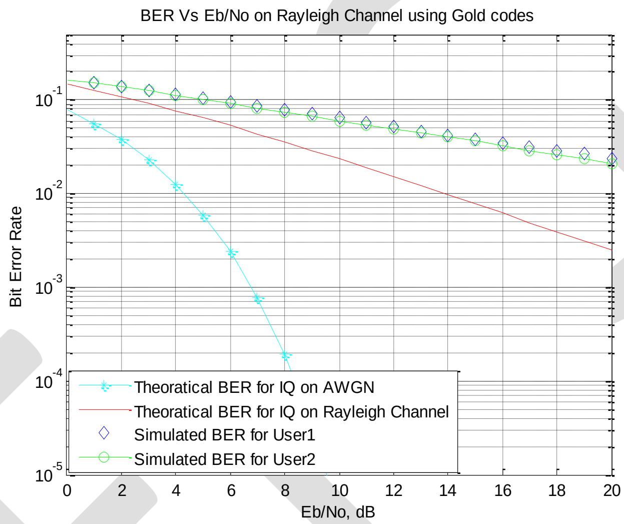


Fig.14.BER Vs Eb/No using Gold code.

In Fig.14 specifies BER of detected user's with Gold code.

VII. CONCLUSION

In MC-CDMA process both Additive White Gaussian Noise (AWGN) and Rayleigh fading channel noises are occur in cellular systems. These noises are evaluated by the performance of MC-CDMA with Long PN sequence, Gold code and Orthogonal Hadamard codes. Simulation is carried out to the performance of MC-CDMA as well as control the bit error rate (BER) as a function of bit energy to noise density ratio (Eb/No). Multicarrier CDMA needs more attention for future implementation on wireless data transmission systems. These codes are unique for each user so data reconstruction is much secured. MC-CDMA features are narrow-band interference rejection, high spectral efficiency, multiple accessing capability, frequency selective channels, simple one-tap equalization and flexibility. From the results Walsh (Hadamard) code has Good Bit Error Rate (BER) and Gold code has efficient Eb/No.

REFERENCES:

[1]. Adit Kurniawan School of Electrical Engineering and Informatics ITB, "Power controlled MC-CDMA in cellular communication systems", Bandung, Indonesia (TSSA) 978-1-4673-4550-7/12, IEEE, 2012.

[2]. Hsiao-Hwa Chen and Wei-Xiao Meng, "A Survey on Complementary Coded MIMO CDMA Wireless", 1553-877X, 2013 IEEE.

[3]. L.J.C.Jr. and Y. G. Li., "Orthogonal Frequency Division Multiplexing for Wireless Channels." GLOBECOM, Nov. 1998. Sydney, Australia.

[4]. H. Bogucka, “Transmission and Reception of the Multicarrier CDMA Signals in the 3rd Generation Mobile Communication Systems,” in IEEE Int. Conf. on Wireless Personal Communications, Feb. 1996. New delhi, India. pp. 319-322.
[5]. Huan Cong Nguyen, Elisabeth de Carvalho and Ramjee Prasad, “Multi-User Interference Cancellation Schemes for Carrier Frequency Offset Compensation in Uplink OFDMA”,IEEE Transactions On Wireless Communications, Vol. 13, No. 3, March 2014.
[6]. Chang-Yi Yang And Bor-Sen Chen, “ MC-CDMA Channel Tracking for FastTime -Varying Multipath Fading Channel”,Fellow IEEE Transactions On Vehicular Technology, Vol. 59, No. 90018-9545, November 2010.
[7]. Elisabeth de Carvalho, and Ramjee Prasad, “ Statistical Precoder Design for Space-Time -Frequency Block Codes in Multiuser MISO-MC-CDMA Systems”, 1932-8184,2014 IEEE.
[8]. Xiaoming Chen and Xiumin Wang “Space-Time-Frequency Block Codes in Multiuser MISO-MC-CDMA Systems”, 2014 IEEE.
[9]. Klein **S.** Gilhousen, “On the Capacity of a Cellular CDMA System Transactions On Vehicular Technology”, Vol. 40, No. *2*, May 1991 IEEE.