Daffodil International University

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Thesis on

Performance Analysis of MC-CDMA with BPSK Modulation and BER Analysis of Rayleigh and AWGN Channel.

A Thesis submitted in partial fulfillment of the requirements for the Award of Degree of Bachelor of Science in Electrical & Electronic Engineering.

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APPROVAL LETTER

This thesis report titled ‘‘Performance Analysis of MC CDMA with BPSK Modulation and BER Analysis of Rayleigh and AWGN Channel’’, submitted by Md. Habibur Rahman ID: 161-33-234, Md. Ali Hridoy ID: 153-33-223 to the Department of Electrical &Electronic Engineering Daffodil International University has been accepted as satisfactory for the partial fulfillment of the requirements for the degree of Bachelor of Science in Computer Science and Engineering and approved as to its style and contents. The presentation has been held on January, 2020.

Board of Examiners

Declaration

We hereby declare that this thesis is based on the results found by ourselves. Materials of work found by other researcher are mentioned by reference. This thesis is submitted to Daffodil International University for partial fulfillment of the requirement of the degree of B.Sc. in Electrical and Electronic Engineering. This thesis neither in whole nor in part has been previously submitted for any degree.

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Acknowledgement

We have benefited from this thesis work. This thesis has been a rewarding knowledge. We have learnt various aspects structure and Analysis of the Bit Error Rate (BER) for a Multi Carrier CDMA wireless communication considering the effect of channels limitations like fading, delay spread etc. Different schemes of MC-CDMA performance result will be evaluated by numerical computations. We take this opportunity to acknowledge assistance of those people who helped us in successful completion of this project and also express our special thanks to our thesis supervisor, Md. Ashraful Haque, Asst. Professor, Dept. of EEE, DIU, for providing us an opportunity with lots of helpful suggestions and format of making this thesis report. Last we express our thanks to all person and friends who always encourage us and provide us support at all times.

December-2019 Md.Habibur Rahman

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Dedicated to

Our Parents

&

Respected Teachers

Abstract

The aim of this project is studying MC CDMA system and use MATLAB to simulate the system and find the signal graphs at each part of the system , how the signal changes after coding and modulation , how the noise effect it at the channel , and how can we receive it by making decoding and demodulation. Also Study the performance of the MC-CDMA system in term of bit error rate with signal to noise ratio (SNR VS BER) for 2 kinds of modulation (BPSK, QPSK) and 2 kinds of channel (AWGN, Fading +AWGN). And make a comparison between all these cases and figure illustrate the cases we use in programming by studying various papers, books, notes as well as internet. Performance degradations due to above system impairments will be evaluated and optimum system design parameters will be determined. To minimize the error, this paper provides a solution which is solved through MATLAB.

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CHAPTER 1

Introduction to Wireless Communication

1.1Introduction:

Wireless communication is the transfer of information over a distance without the use of electrical conductors or "wires". The distances involved may be short (a few meters as in television remote control) or long (thousands or millions of kilometers for radio communications).At the point when the setting is clear, the term is frequently abbreviated to "remote". Remote correspondence is commonly viewed as a part of broadcast communications. It envelops different kinds of fixed, versatile, and compact two-way radios, cell phones, individual computerized associates (PDAs), and remote systems administration. Different instances of incorporate GPS units, carport entryway openers as well as carport entryways, remote PC mice, consoles and headsets, TV and cordless phones. Remote tasks grants administrations, for example, long range interchanges, that are outlandish or unreasonable to actualize with the utilization of wires. The term is normally utilized in the broadcast communications industry to allude to media communications networks (for example radio transmitters and recipients, remote controls, PC systems, arrange terminals, and so on) which utilize some type of vitality (radio recurrence (RF), infrared light, laser light, obvious light, acoustic vitality, and so forth) to move data without the utilization of wires. Data is moved as such over both short and long separations. Radio transmission through the air. Remote is an exceptionally conventional term that alludes to various types of transmission that don't utilize metal wires or optical strands. They incorporate AM and FM radio, TV, mobile phones, compact telephones and remote LANs. Different systems are utilized to give remote transmission, including infrared viewable pathway, cell, microwave, satellite, parcel radio and spread range. See arrange, cell, remote glossary, remote LAN, CMRS, PCS, FDMA, TDMA, CDMA and CDPD.

1.2Multiple Access technologies:

Numerous Accesses is where numerous endorsers or nearby stations can share the utilization of the utilization of a correspondence channel simultaneously or about so notwithstanding the reality start from broadly various areas. A channel can be characterized as a segment of the restricted radio asset, which is briefly designated for a particular reason or client, for example, somebody's telephone call. A various access technique is a meaning of how the radio range is separated into channels and how the channels are assigned to the numerous clients of the networks. There are three fundamental systems of numerous gets to:

Frequency Division Multiple Access (FDMA)

Time Division Multiple Access (TDMA)

Code Division Multiple Access (CDMA)

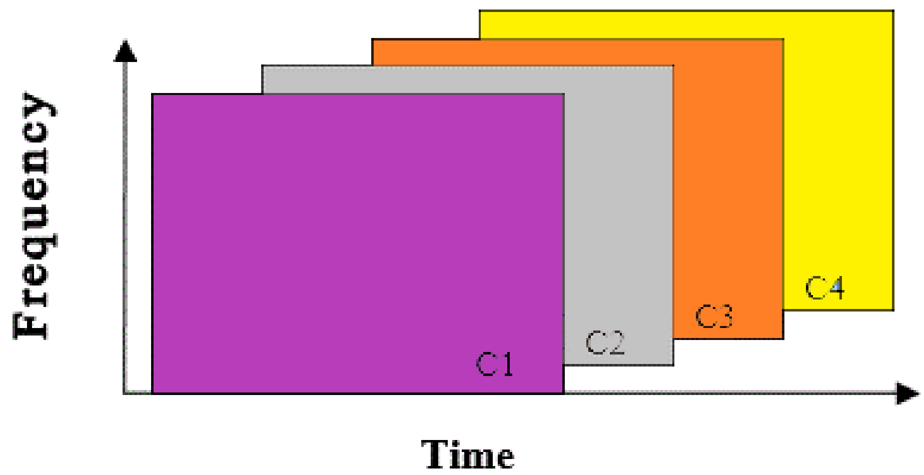
In media communications and PC organizes, a channel get to technique or various access strategy permits a few terminals associated with the equivalent multi-guide transmission toward transmit over it and to share its ability. Instances of shared physical media are remote systems, transport systems, ring systems, center point systems and half-duplex point-to-point joins. A channel-get to conspire depends on a multiplexing technique,that permits a few information streams or motion toward share a similar correspondence channel or physical medium. Multiplexing is in this setting gave by the physical layer. Note that multiplexing additionally might be utilized in full duplex highlight point correspondence between hubs in an exchanged system, which not be considered as various gets to. A channel-get to plot is likewise founded on a different access convention and control component, otherwise called media get to control (MAC). This convention manages issues, for example, tending to, allotting multiplex channels to various clients, and maintaining a strategic distance from crashes. The MAC-layer is a sublayer in Layer 2 (Data Link Layer) of the OSI model and a part of the Link Layer of the TCP/IP model

.

1.2.1 Code Division Multiple Access (CDMA):

Code Division Multiple Access (CDMA) is a channel access method utilized by various radio communication technologies. It should not be confused with the mobile phone standards called CDMA One and CDMA2000 which are often referred to as simply, which use CDMA as an underlying channel access method.

One of the essential ideas in information correspondence is enabling a few transmitters to send data at the same time over a solitary correspondence channel. This enables a few clients to share a data transfer capacity of various frequencies. This idea is called multiplexing. CDMA utilizes spread-range innovation and an exceptional coding plan where every transmitter is doled out a code to enable various clients to be multiplexed over the equivalent physical channel. On the other hand, time division various access (TDMA) partitions access by time, while recurrence division different access (FDMA) separates it by recurrence. CDMA is a type of spectrum. Since the tweaked coded signal has an a lot higher information transfer speed than the information being conveyed.



1.1Figure: Code Division Multiple Access

A similarity to the issue of numerous entrance is a room (channel) in which individuals wish to speak with one another. To keep away from disarray, individuals could alternate talking, talk at various pitches, or communicate in various dialects. CDMA is similar to the last model where individuals communicating in a similar language can see one another, however not others. CDMA system is two parts:

1. Direct Sequence Code Division Multiple Access (DS-CDMA)
2. Frequency Hopping Code Division Multiple Access (FH-CDMA)

1.2.2 Basic Concept:

In code division different access (CDMA) network, the narrowband signal is increased by an exceptionally huge transfer speed signal called the spreading signal. All CDMA clients utilize a similar transporter recurrence and may transmit at the same time which we find in figure. Every client has its own pseudorandom code word. The recipient plays out a period relationship activity to identify just the particular wanted code word. All other code word show up as commotion. Every client works freely with no information on different clients.

CDMA procedures where each channel is doled out a special pseudo clamor code. The close far issue happens when numerous versatile clients share a similar channel. By and large, the most grounded got portable sign will catch the demodulator at a base station. In CDMA, more grounded got signal levels raise the commotion floor at the base station demodulators for the more fragile sign, along these lines diminishing the likelihood that more fragile sign will be gotten. To defeat this issue, control is utilized.

Power control is given by each base station in a phone framework and guarantees that every portable inside the base station inclusion region gave a similar sign level to the base station collector. There are three different ways to spread the data transmission of the sign:

The sign is quickly exchanged between various frequencies inside the jumping data transfer capacity pseudo-haphazardly, and the collector realizes where to locate the sign at some random time.

Basic Principles of CDMA

Rate of data signal= D

Break each bit into k chips

Chip data rate of new channel =KD

CDMA Example

If k=6 and code is a sequence of 1s and -1s

For a ‘1’ bit, code as chip pattern sends A

<c1, c2, c3, c4, c5, c6>

For a ‘0’ bit, complement of code sends A

<-c1, -c2, -c3, -c4, -c5, -c6>

Receiver knows sender’s code and performs function

<d1, d2, d3, d4, d5, d6> = received chip pattern

<c1, c2, c3, c4, c5, c6> = sender’s code ( )

CDMA Example

User A code = <1, –1, –1, 1, –1, 1>

To send a 1 bit = <1, –1, –1, 1, –1, 1>

To send a 0 bit = <–1, 1, 1, –1, 1, –1>

User B code = <1, 1, –1, – 1, 1, 1>

To send a 1 bit = <1, 1, –1, –1, 1, 1>

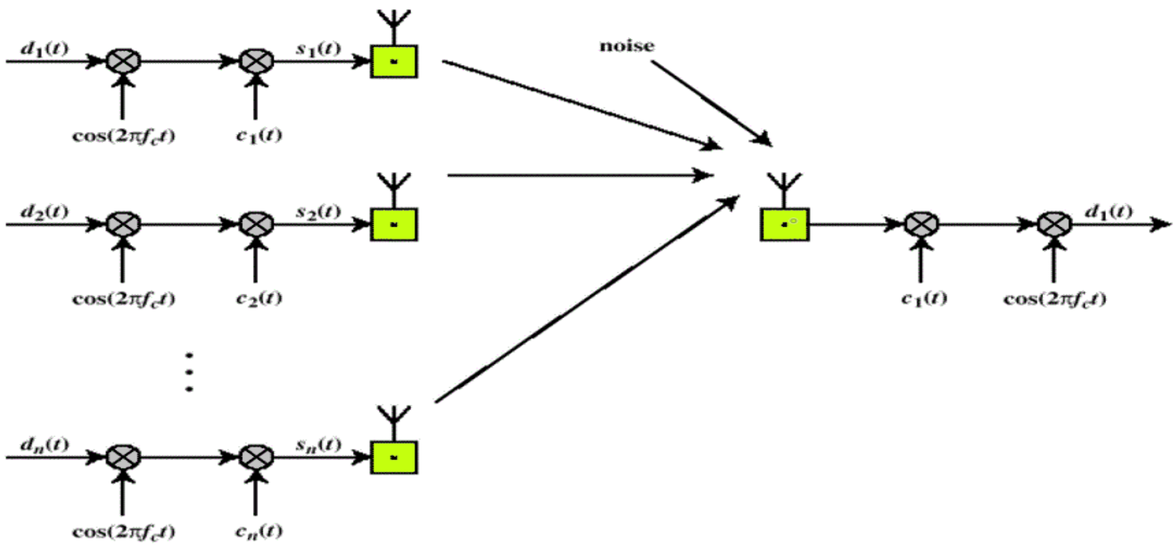
Receiver receiving with A’s code

(A’s code) x (received chip pattern)

• User A ‘1’ bit: 6 -> 1

• User A ‘0’ bit: -6 -> 0

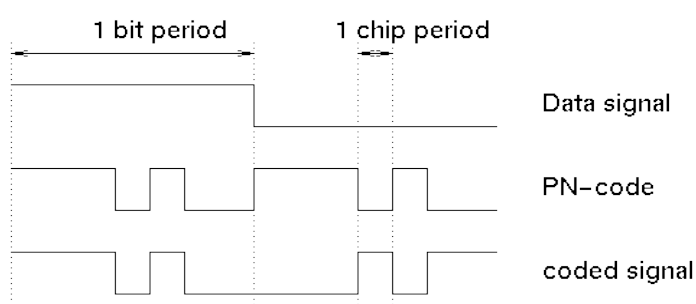
• User B ‘1’ bit: 0 -> unwanted signal ignored



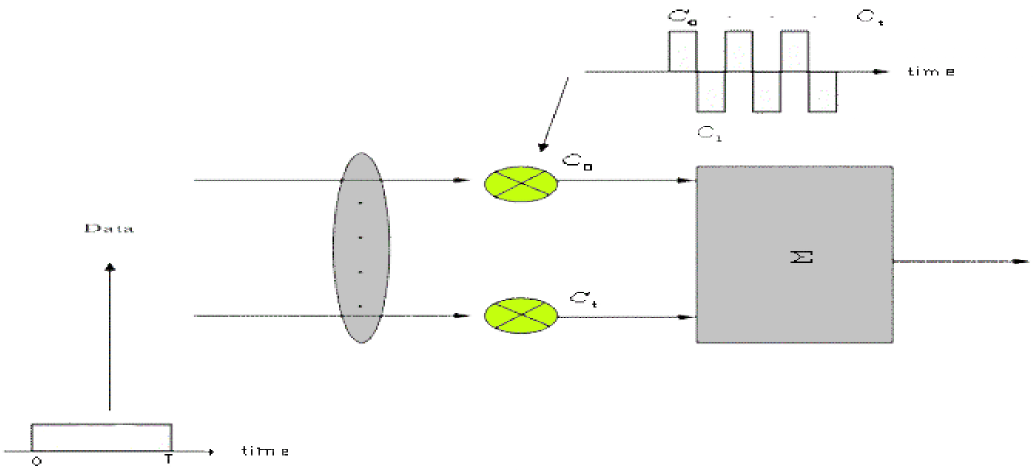
1.2Figure: Basic Principles of CDMA

1.2.3 Direct Sequence Code Division Multiple Access (DS-CDMA):

In Direct Sequence spread range transmission, the customer data signal is expanded by a code plan. Generally, parallel groupings are used. The range of a part in the code is known as the "chip time". The extent between the customer picture time and the chip time is known as the spread factor. The transmit signal includes a transmission limit that reciprocals the spread factor times the exchange speed of the customer data.

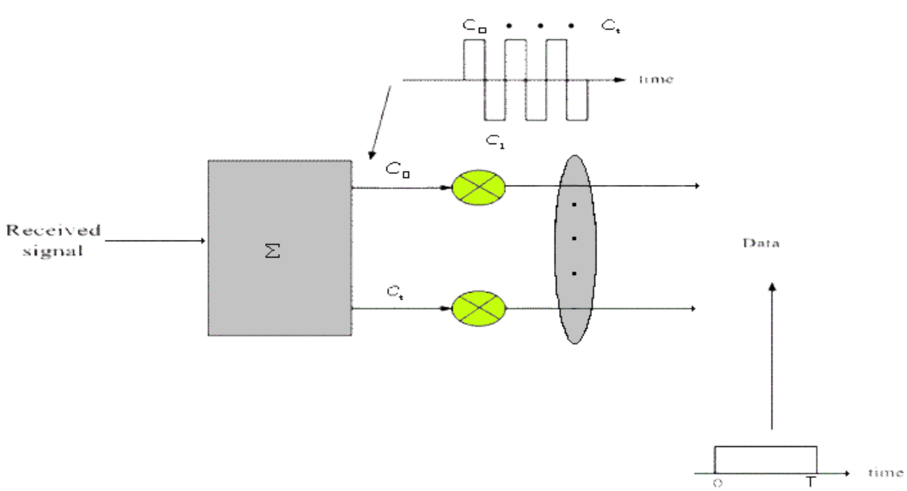


In the gatherer, the got sign is again copied by the identical (synchronized) code. This action empties the code, so we recover the transmitted customer data. Differing CDMA customers use different codes. In this model the gatherer sees the sign from customer 1, while the sign from customer 2 is seriously diminished by the correlator (multiplier and integrator) in the beneficiary.



1.3Figure: Direct Sequence Code Division Multiple Access transmitter

In the authority, the got sign is again copied by the proportional (synchronized) code. This action clears the code, so we recover the transmitted customer data. Different CDMA customers use different codes. In this model the gatherer sees the sign from customer 1, while the sign from customer 2 is seriously diminished by the correlator (multiplier and integrator) in the recipient.A CDMA recipient can recoup the required sign by copying the get signal with a comparable code as the one used during transmission.where c1 is the code course of action used by customer 1, Tc is the chip range, td is a commonplace time adjusted shared among transmitter and authority and N is the length of the code gathering.. Note that the get code must be wonderfully time agreed with the transmit code.

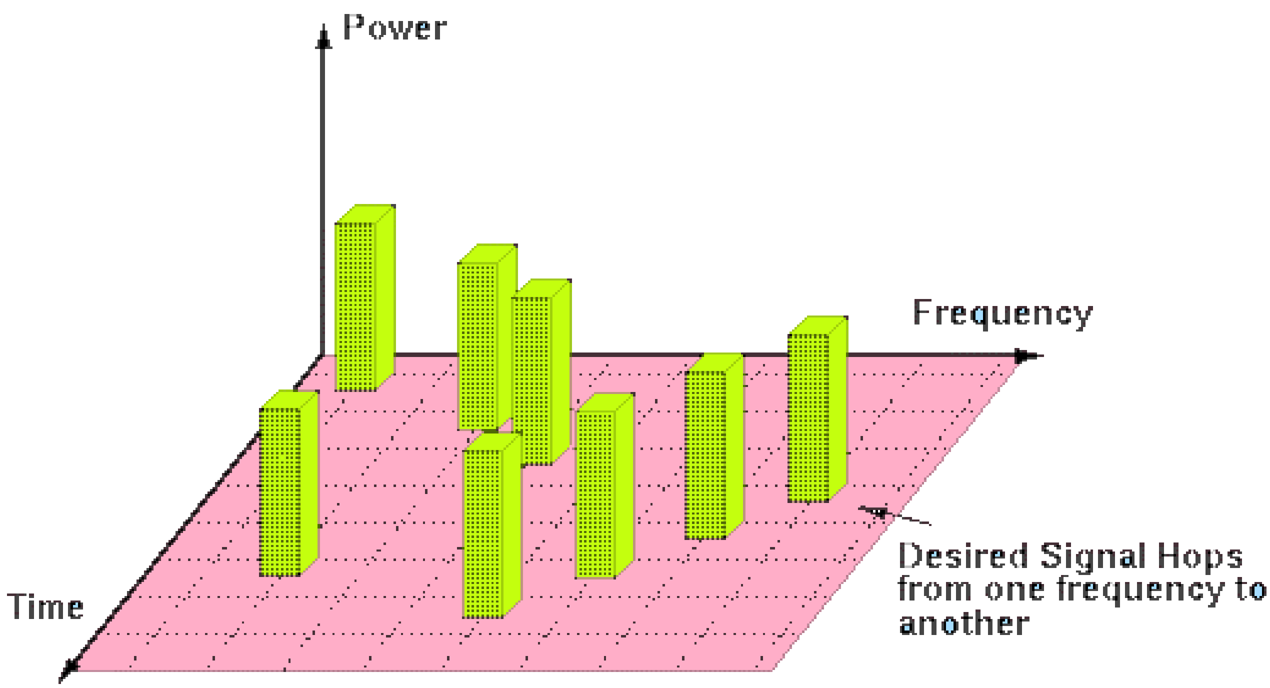


1.4Figure Direct Sequence Code Division Multiple Access receiver

1.2.4 Frequency Hopping Code Division Multiple Access (FH-CDMA):

FH – CDMA is a kind of spread range advancement that enables various customers to have a comparable channel by using an uncommon bobbing guide to perceive different customers' transmission. The sort of spread range wherein the conveyor bobs subjectively beginning with one repeat then onto the following is called FH spread range. A run of the mill guideline association for FH system is that of M-ary repeat move keying (MFSK).

A huge great situation of repeat skipping is that it might be completed over a significantly greater repeat band than it is possible to execute DS-spreading, and the band can be noncontiguous. Another noteworthy favored position is that repeat hopping gives assurance from different – get to impedance while not requiring power control to envision close – far issues. In DS – structures, exact power control is basic anyway ends up being less suitable as the transporter repeat is extended.



1.5Figure: Frequency Hopping Code Division Multiple Access

Immediately, in recurrence bouncing networks, the transmitter changes the conveyor repeat as showed by a specific hopping structure. The favored position is that the sign sees a substitute channel and a substitute plan of interfering sign during each skip. This keeps up a vital good ways from the issue of besieging correspondence at a particular repeat. There are two central sorts of repeat skipping. A touch of elbowroom is that sound data area is possible. Normally, systems using moderate hopping moreover use (burst) screw up control coding to restore loss of (various) bits in a solitary skip.

1.3 Limitation of communication system with CDMA techniques:

Communication system has some limitation. Bandwidth, Noise and Fading are some major limitation.

Data transfer capacity is the estimation of a specific recurrence extend. At the point when we fixed a transmission capacity for a channel then we transmit that measure of information in one moment of time. So in the event that the recurrence run is high, at that point we can transmit or get more information for a time of time. Lack of transfer speed implies absence of throughput of coherent information. Data transmission confinement implies limiting the amount of data transmitted from sender to beneficiary every second. This implies the data shows up more slow, or the data contains less detail.

Commotion will likewise influence comprehensibility. The commotion is added substance, the got sign equivalents the transmit signal in addition to some clamor, where the commotion is factually autonomous of the sign.

Blurring is a change in the got sign quality at the beneficiary or an arbitrary variety in the got sign is known as blurring. Blurring of radio waves is the undesired variety in the power or commotion the waves got at the recipient. There are two sorts of blurring confinements. Recurrence particular blurring and Time Selective Fading.

1.4 Objective of the Thesis Work:

Work to be carried out for analysis of MC CDMA system with fading and interference. Different schemes of MC-CDMA will be considered and performance result will be evaluated. To evaluate the performance results in terms of Bit Error Rate. To determine the optimum system parameters at a given system BER.

Chapter 2

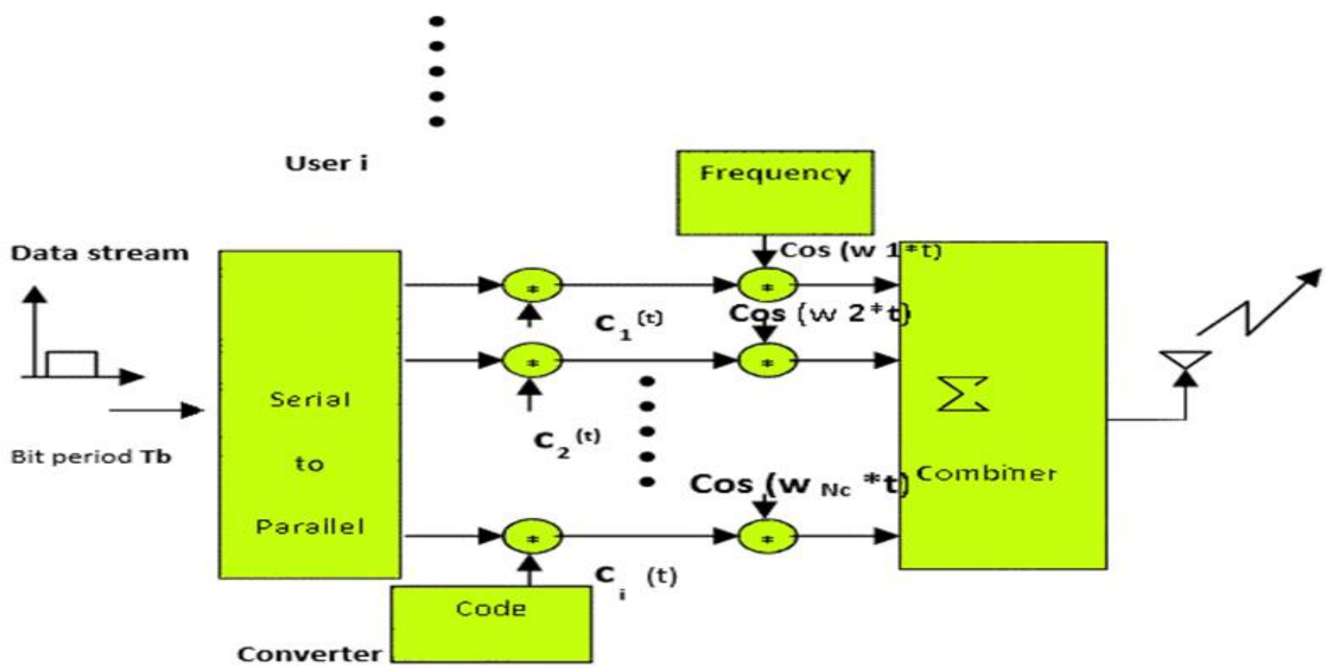
DS CDMA channels and Modulation

2.1 Introduction:

In this section, we will see the kind of advanced adjustment and direct that we use in our examination. Where we will talk about right off the bat the kind of balance and two essential sort of correspondence channel.

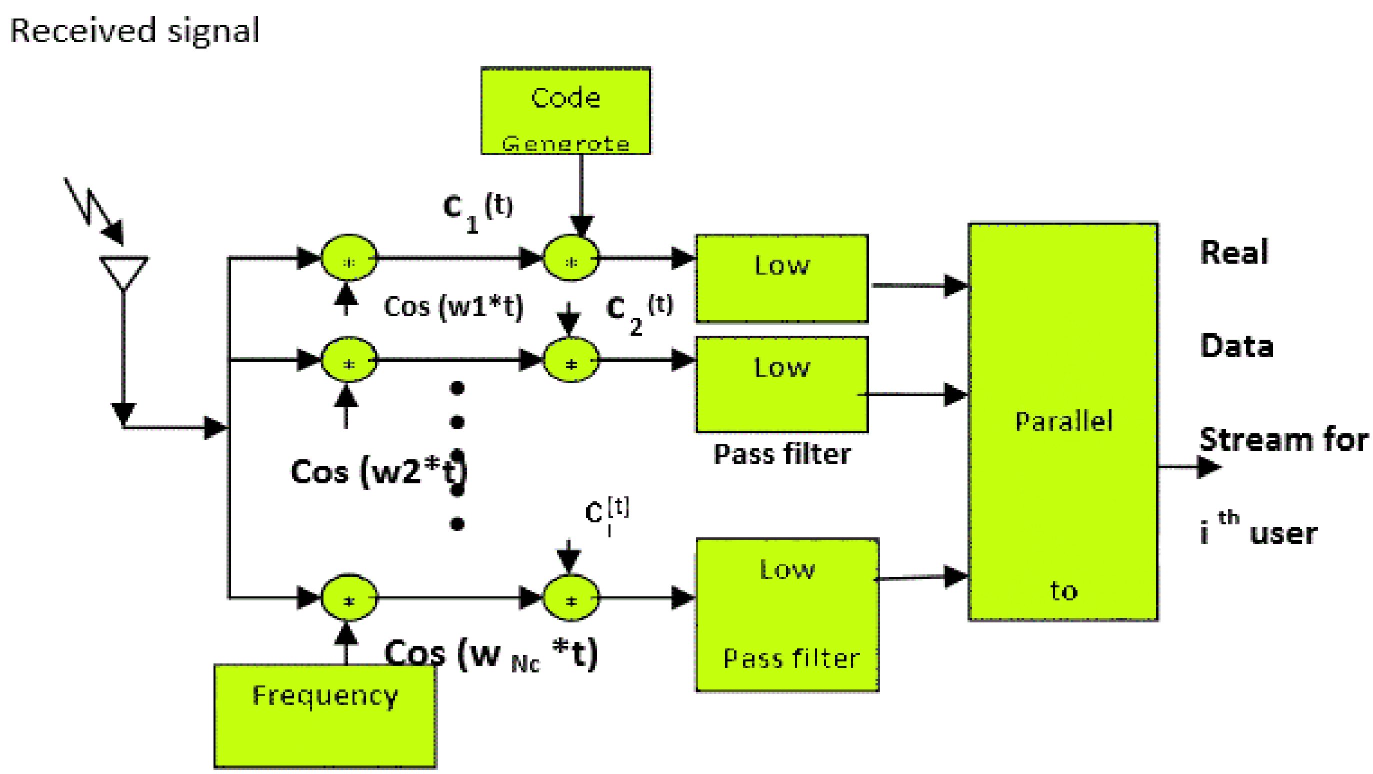
2.2Multi Carrier Code Divisions Multiple Accesses (MC-CDMA):

Multi Carrier Code Division Multiple Access (MC-CDMA) is a modestly new thought. Its progression went for improved execution over multipath joins. MC-CDMA is a guideline strategy that uses multi carrier transmission of DS-CDMA type signals. A MC-CDMA transmitter spreads the firs data stream in the repeat zone over different sub bearers using a given spreading code. In this structure the sub bearers pass on a comparable information in a steady progression. The MC-CDMA offers better repeat arranged assortment to fight repeat explicit obscuring.



2.1Figure: MC-CDMA transmitter

We see the transmitter MC-CDMA network for i number of client. The MC-CDMA transmitter spreads the principal data stream using a given spreading code in the repeat territory. The code generator makes particular exceptional codes for every special customer and a while later combines together. By then the repeat generator joins various transporter repeat to the data sign and a short time later solidifies the entire sign together by a combiner. In the wake of joining all of the sign the CDMA radio wire transmits the give up the remote media.



2.2Figure: MC-CDMA receiver

In figure the MC-CDMA beneficiary is structured by the limit of i number of client. MC-CDMA collector additionally gets the transmitted sign summation of i number of clients. Demodulates the got sign by a similar profession recurrence of each sign and afterward the sign duplicate with the particular codes given by the recipient code generator. At that point we get the sign of i_{th} client which is same for transmitter and beneficiary. Low pass channel expel the high frequencies part of the sign. At last, the P/S converter introduces the genuine advanced information signal.

2.3Analysis of MC CDMA:

Here we talk about the Bit Error Rate on the MC-CDMA network. Subsequent to joining the transmitted sign flag the CDMA reception apparatus transmits the sign over the remote media. In recipient side we get the all brushing sign with some surprising sign which are MUI, ICI and Noise signal. So in the recipient side subsequent to joining all sub-bearer signals we get the got signal is,

$$x = x_0 x_{MUI} x_{ICI} x_{noise} \text{……………………………………………………………………………[1]}$$

x_0= wanted signal

x_{MUI}= multi-user interference

x_{ICI}= inter-carrier interference

x_{noise} = noise

We can write the signal as

$$x_0 = b_o \frac{T_s}{N} [\sum_{n=o}^{N-1} \beta_{n,n} \omega_{n,n} + \sum_{m \neq 0} \sum_{n=o}^{N-1} \beta_{n,n} \omega_{n,n} c_0 [n] c_0 [n - m]] \text{………………………………………………………………………………………[2]}$$

N = number of subscriber

n = subscriber number

$\beta_{n,n}$= crosstalk between the user.

T_s= Sampling time

$\omega_{n,n}$= weight factors which is constant.

$c_0 [n] c_0 [n - m]$= orthogonal spreading codes

The variance of x_0 became zero for large number of N, the system working like non fading channel.

The multi-user interference signal is

$$x_{MUI} = T_s \sum_{K=1}^{N-1} b_k [\sum_{n=o}^{N-1} \beta_{n,n} \omega_{n,n} c_0 [n] c_k [n]] \text{……………………………[3]}$$

$$or, \ x_{MUI} = T_s \sum_{K=1}^{N-1} b_k [\sum_{n \in A_+} \beta_{n,n} \omega_{n,n} \sum_{n \in A_-} \beta_{n,n} \omega_{n,n}] \text{……………..[4]}$$

$A_{-} = \{n: c_j\,[n]c_k[n] = -\frac{1}{N}\}$ is the sets of orthogonal code of the sub career index n

$A_{+} = \{n: c_j\,[n]c_k[n] = \frac{1}{N}\}$ is the sets of orthogonal code of the sub career index n

$$and \quad \sum_{A_{+}\cup A_{-}} c_j\,[n]c_k[n] = 0$$

So the variance of MUI,

$$\sigma_{MUI}^2 = E_{ch}E_{MUI}x_{MUI}^*$$

Or, $\sigma_{MUI}^2 = \frac{(N-1)T_s}{N^2}[E_{ch}\left(\sum_{n\in A_{+}} \beta_{n,n}\omega_n\right)^2 + E_{ch}\left(\sum_{n\in A_{-}} \beta_{n,n}\omega_n\right)^2 - 2E_{ch}\,(\sum_{n\in A_{+}} \beta_{n,n}\omega_n) \times \left(\sum_{n\in A_{-}} \beta_{n,n}\omega_n\right)]$..[5]

fading of the sub-carriers is independent ,so

$E_{ch}\left(\sum_{n\in A_{+}} \beta_{n,n}\omega_n\right)^2 = \frac{N}{2}M_{22} + \frac{N}{2}\left(\frac{N}{2} - 1\right)M_{11}^2$ ....[6]

$and\ , E_{ch}\left(\sum_{n\in A_{+}} \beta_{n,n}\omega_n\right) \times \left(\sum_{n\in A_{+}} \beta_{n,n}\omega_n\right) = \left(\frac{N}{2}\right)^2 M_{11}^2$............[7]

Where

M11=$P_o\ /N_o$

M22=$2P_o^2\ /N_o^2$

Po = power of the signal

No= power of the noise signal

After simplify all the equation we get the variance,

$\sigma_{MUI}^2 = \frac{(N-1)T_s^2}{N^2}(M_{22} + M_{11}^2)$...[8]

The ICI comes from the crosstalk between sub carriers. Inter-carrier interference signal is,

$x_{ICI} = T_s\sum_{n=1}^{N-1} a_n \sum_{\Delta\neq O} \beta_{n+\Delta,n}\omega_{n+\Delta,n+\Delta}c_0\,[n + \Delta]$..........................[9]

Δ = distance of signal between two subscriber, Now after putting $a_n = \sum_k c_k[n] b_k$ in the equation,

$$x_{ICI} = \sum_{\Delta \neq O} \sum_{n=o}^{N-1} \sum_{K=O}^{N-1} b_k c_k[n] \beta_{n+\Delta,n} \times \omega_{n+\Delta,n+\Delta} c_0 [n+\Delta] \text{.......[10]}$$

So the variance of ICI, $\sigma_{ICI}^2 = E_{ch}\, E x_{ICI}\, x_{ICI}^*$

$$or, \sigma_{ICI}^2 = T_s^2 E_{ch} E[\sum_{m=1}^{N-1} \sum_{k=1}^{N-1} b_k \sum_{n=o}^{N-1} \beta_{mn} \omega_n c_o(n) c_k(n-m)]^2 \text{.......[11]}$$

After simplify the equation we get the variance

$$\sigma_{ICI}^2 = \sum_{\Delta \neq 0} p_\Delta M_{02} T_s^2 \text{.......[12]}$$

$$M_{02} = E\beta_{n,n}^2 / N_O^2 = P_O / N_O^2$$

$p_\Delta =$ variation of the signal power between of any two subscriber.

The variance of the noise collected over all sub-carriers $\omega_{n,n}$ becomes,

$$\sigma_{noise}^2 = N M_{02} N_O T_s \text{.......[13]}$$

So, $\frac{E_N}{N_O} = \frac{M_{11}^2 T_S^2}{\sigma_{ICI}^2 + \sigma_{MUI}^2 + \sigma_{noise}^2}$

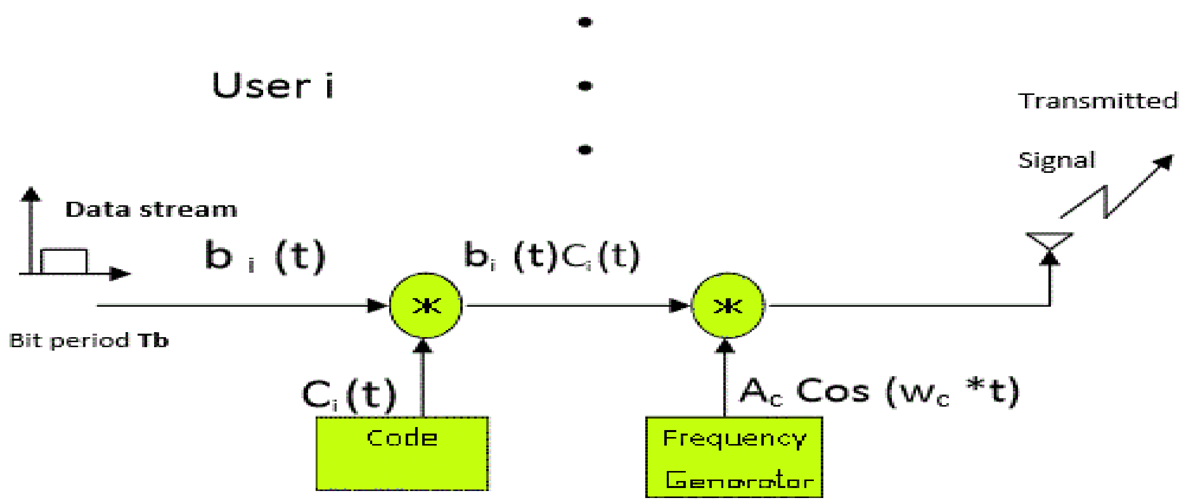
$$= \frac{M_{11}^2}{(M_{22} + M_{11}^2) + M_{02}\, [\sum_{\Delta \neq 0} p_\Delta + \frac{N_O}{T_S}]} \text{.......[14]}$$

Since we consider many different channels $x_{MUI} x_{ICI} x_{noise}$
are zero-mean complex Gaussian.so,

$$\text{BER, } B = \frac{1}{2} erfc \sqrt{\frac{E_N}{N_O}} \text{.......[15]}$$

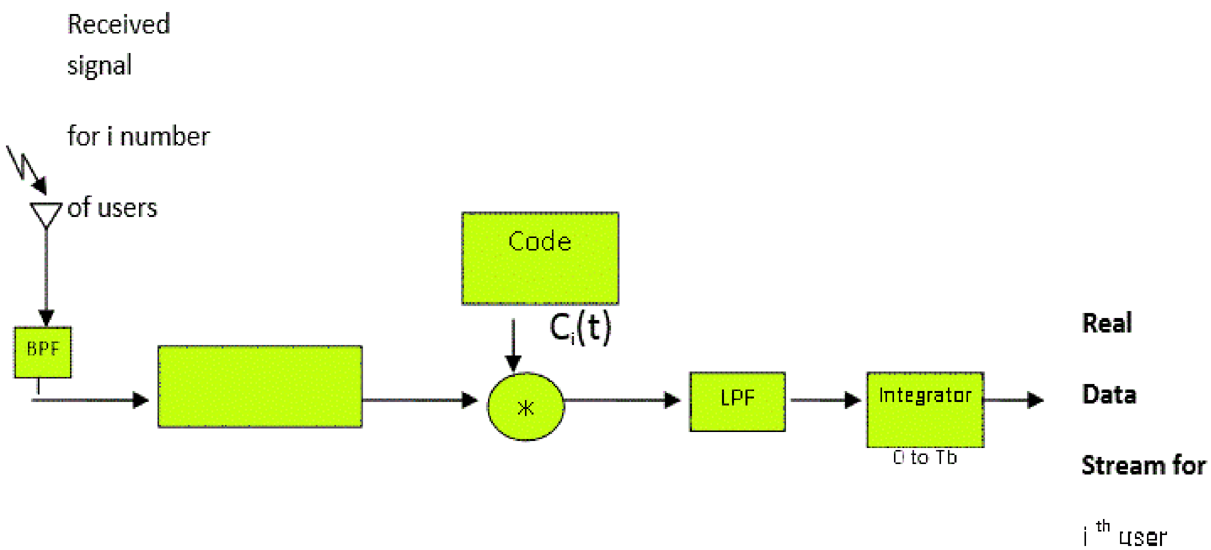
2.4 Direct Sequence Code Division Multiple Access (DS-CDMA):

Direct arrangement code division numerous entrance (DS-CDMA) is an alluring distribution method that enables clients to be at the same time dynamic over the complete accessible transfer speed. In Direct Sequence CDMA framework transmission, the client information signal is duplicated b pseudo arbitrary code arrangement.



2.3Figure: DS-CDMA transmitter

In figure the DS CDMA transmitter is structure by the limit of I number of client. The DS CDMA transmitter consolidates the first information stream utilizing a given spreading code in the time space. Here, t is time, bi(t) is the information stream of ith client Ci (t) is the pseudo arbitrary code. bj(t)Ci(t) is ith client information stream after consolidates the code width. The transmitter creates one of a kind code for every client more than one piece period; Tb by the Code Generator, The Frequency Generator produces one bearer recurrence {Ac Cos (wc *t)} for every client for stage move keying regulation strategy. In the wake of consolidating and regulation of advanced information, it is transmitted by the CDMA recieving wire over the remote media like air.

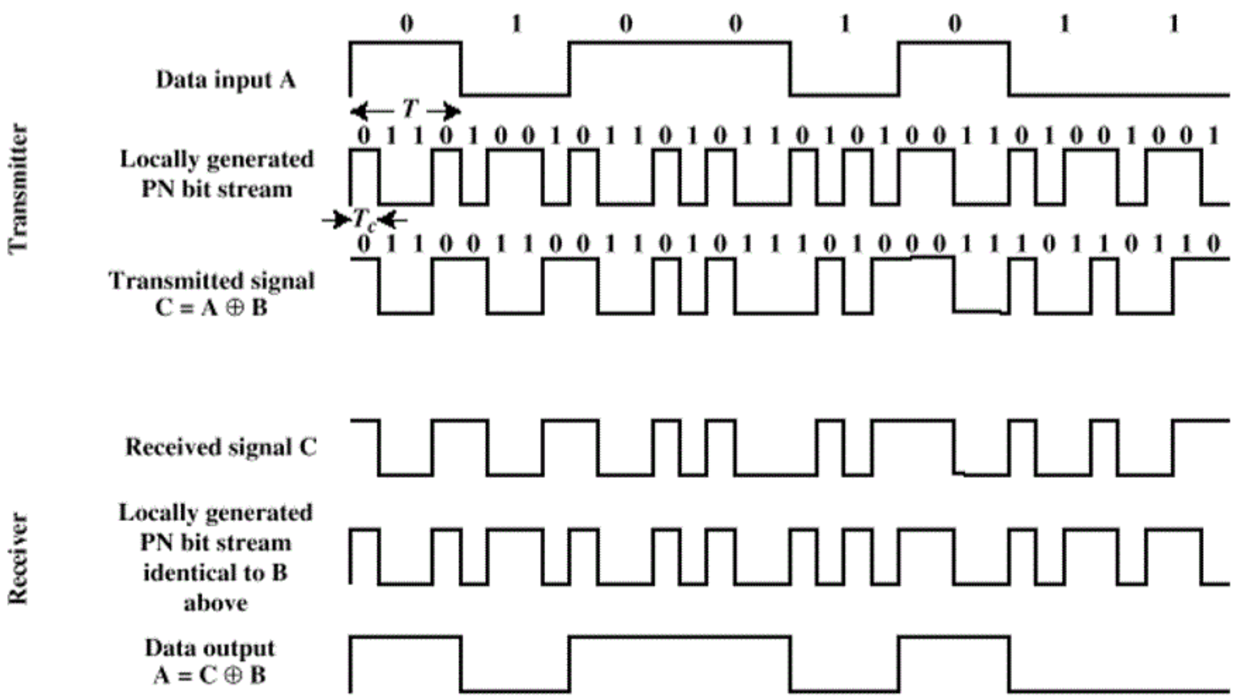


2.4Figure: DS-CDMA transmitter

In figure the DS-CDMA recipient is planned by the limit of i number of client. At that point it will confront the MAI for client 1 to client (i-1). At First the CDMA radio wire got the transmitted sign and afterward it goes through a band pass channel (BPF). BPF evacuate any undesirable sign. Demodulator demodulates the sign with {Ac Cos (wc *t)}. At that point the got sign is again duplicated by a similar code Ci(t). After this the code has been expelled, so we get the first transmitted client information. The low pass channel dismisses the high recurrence part of information signals. Finally, the integrator gives the genuine ith client computerized information. Integrator decreases the multi-get to impedance (MAI).

2.4.1Direct Sequence Spread Spectrum (DSSS):

Each piece in unique signal is spoken to by different bits in the transmitted sign Spreading code spreads signal over a more extensive recurrence band o Spread is in direct extent to number of bits.



2.5Figure: Direct Sequence Spread Spectrum

2.5 BPSK Modulation (Binary phase shift keying):

BPSK is a band pass computerized tweak network or 2-ary nonstop wave (c_w). Information are spoken to by two sign with various stage. The transporter stage change as indicated by input bit. On the off chance that the info bit 1, 0 the stage change for 0,180 regarding the transporter. Where the two sign.

S1(t)= A cos $2\pi f_c t$, $0<t<T$ for 1

S2(t)=-A cos $2\pi f_c t$, $0<t<T$ for 0

These two sign lead to least mistake likelihood for a similar Eb/N since they have a relationship coefficient of - 1. It has a similar recurrence and vitality.

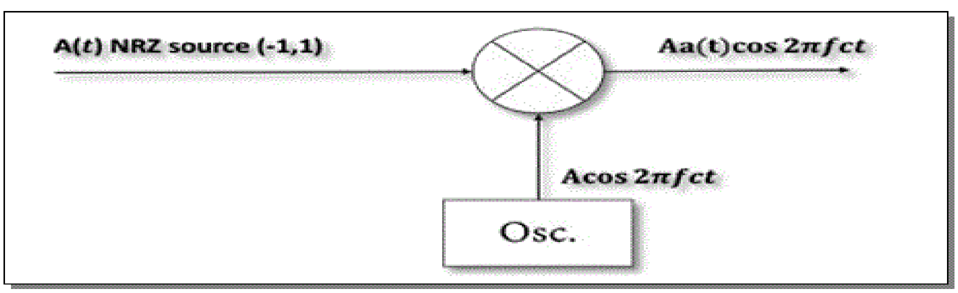
The wave type of information stream (101010) created by BPSK modulator. The sign has a consistent recurrence, the stage isn't persistent at the limit of bit when move from 1 to 0 and the other way around as appeared.

To change in stage at 0 and the recurrence of the transporter must be a number different of the bit rate (fc = m R_b) where m is a whole number R_b is the bit rate. In the event that m not whole number the stage would not be at 0 or π.

BPSK Modulator: Transmitter in BPSK basic stream of bipolar information bits a(t) increase by sinusoidal transporter at modulator and afterward signal transmit as BPSK signal as appeared. The paired information got by.

$$a(t) = \sum_{n=-\infty}^{\infty} an\, p(t - nT)$$

Where either -1 or 1, it's pulse defined in [0, T].



BPSK Demodulation: The reasonable demodulator of BPSK falls in the class of sound indicators for double sign. Coordinated channel or maker could be structure the cognizant locator, figure shows recipient utilizing connect it's reference signal s(t) = 2Acos 2πfct produced via transporter recuperation (CR) circuit as distinction signal. The got sign and the reference signal must be synchronous in recurrence and stage.

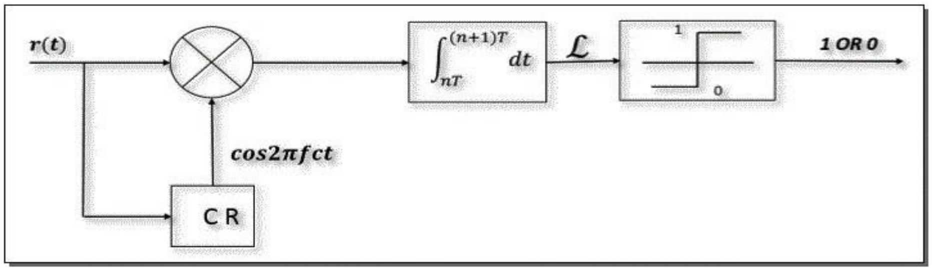
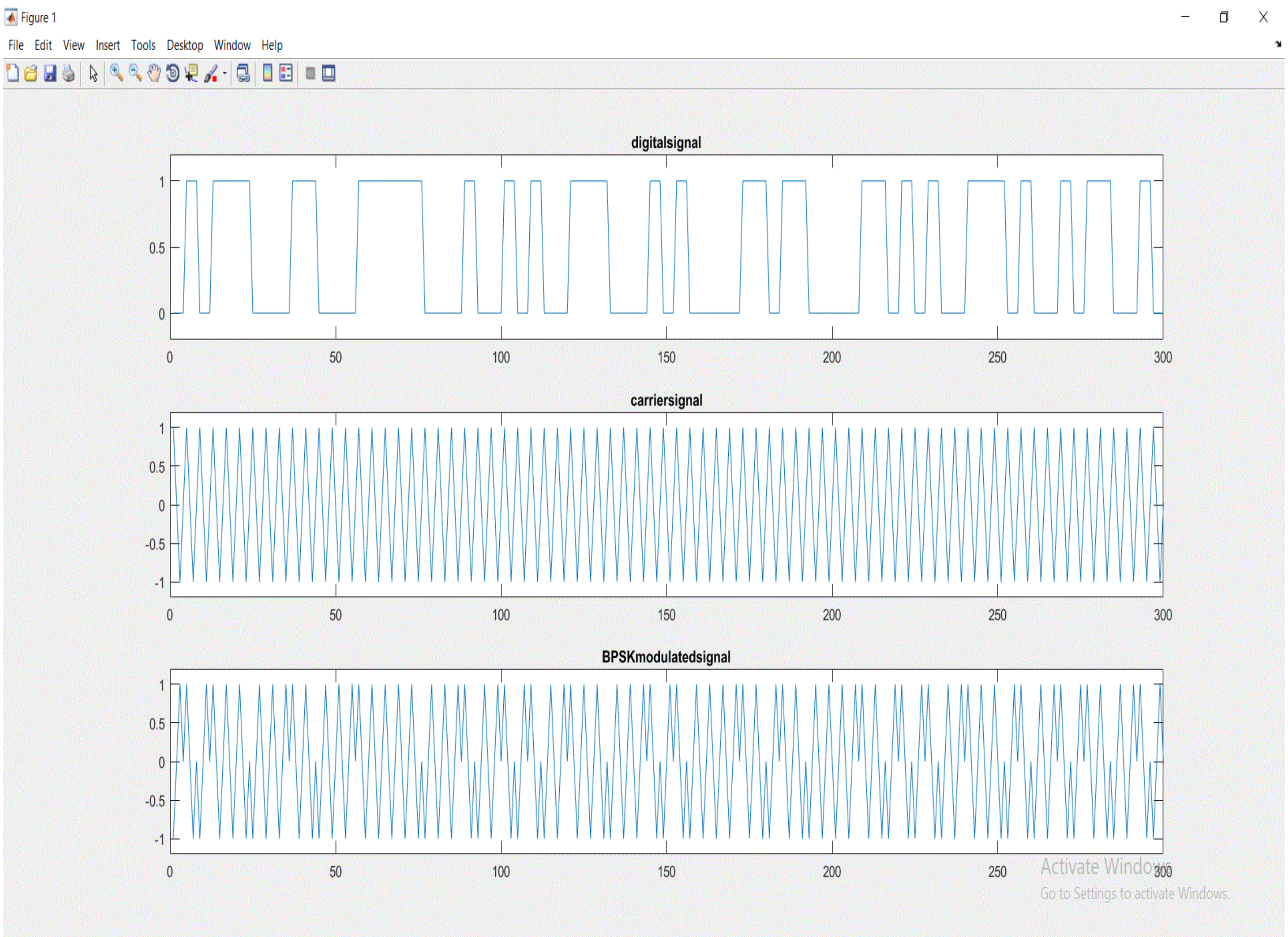


Figure Using Correlator is favored than coordinated channel in passband since a channel with h (t) = cos2πfc (T −t) is hard to actualize.

BPSK modulated signal by using MATLAB:



2.6Figure: BPSK modulated signal of MC CDMA

Error : If the transmitted sign per bit (Eb) increment for explicit clamor ghostly thickness then the likelihood of blunder Pb is correspondingly diminish as per the condition roar.

$$P_b = \frac{1}{2} erfc\left(\sqrt{\frac{Eb}{N_o}}\right)$$

2.6 Channels:

Characteristic of channel is an important role for designing the modulation scheme. To check the performance of modulation it is test on different channels and then the modulation scheme are chosen for channel that it is performance is better than the other scheme. Model of channel are very famous model in mobile communication.

AWGN channel Additive white Gaussian noise (AWGN) channel is a common channel model in the modulation schemes. In this model, white Gaussian noise are add to the signal through the channel. This mean that the frequency response for channel's amplitude is flat (thus with infinite bandwidth) and frequency response for channel's phase is linear for all frequencies so that modulated signals pass through the channel without any phase distortion and amplitude loss. In AWGN channel, fading does not exist, only distortion is included. So the received signal can written as.

$$r(t) = s(t) + n(t)$$

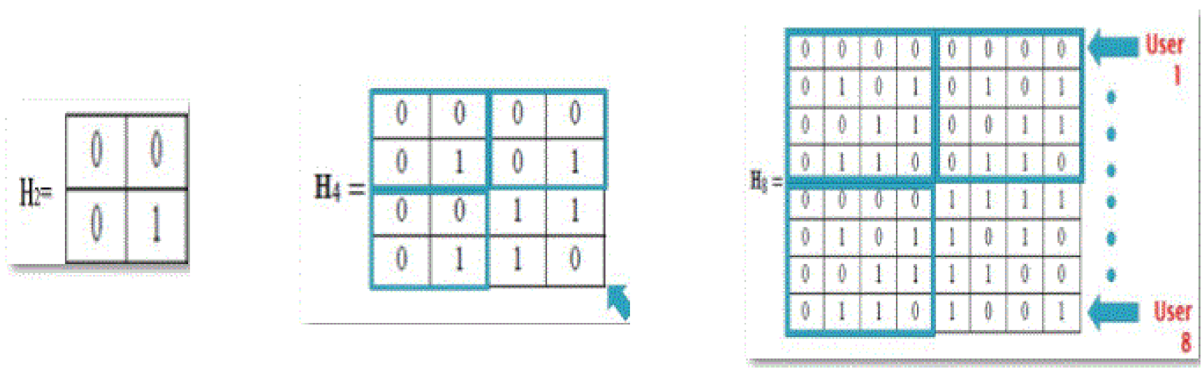
The AWGN does not exist in nature since any channel not have an infinite bandwidth, so that it is used when signal bandwidth less than channel bandwidth. Channels are approximate to AWGN channel for example wideband coaxial cable because it has only Gaussian noise. When the weather is good the line of sight (LOS) radio channel, including fixed satellite links and fixed terrestrial microwave links, are approximate to AWGN channels.

Fading channel

Fading is a marvel happens when the stage and plentiful ness of a radio sign change rapidly over brief time interim or travel separation. Blurring happened when at least two variants of transmitted sign have a similar recurrence and marginally various occasions meddle with one another. These adaptations called multipath waves, meet each other at reception apparatus of beneficiary to give a sign change generally in stage and sufficiency. The multipath signals considered diverse sign in the event that it postpone longer than an image period. In portable station, for example, satellite versatile station, blurring and multipath impedances are happen when the transmitted sign reflect from the structures and landscapes around it. Furthermore, the relative movement between the transmitter and collector, and the movement of item around the sign, similar to a vehicle. In any case, if the encompassing items move at a speed not exactly the portable unit, their impact can overlooked .Practically there are many sort of blurring relying upon the data transmission channel comparing to flag transfer speed and the measure of postponement of transmitted sign and another parameter called Doppler spread. In our examination we simply utilize just on type, called level blurring.

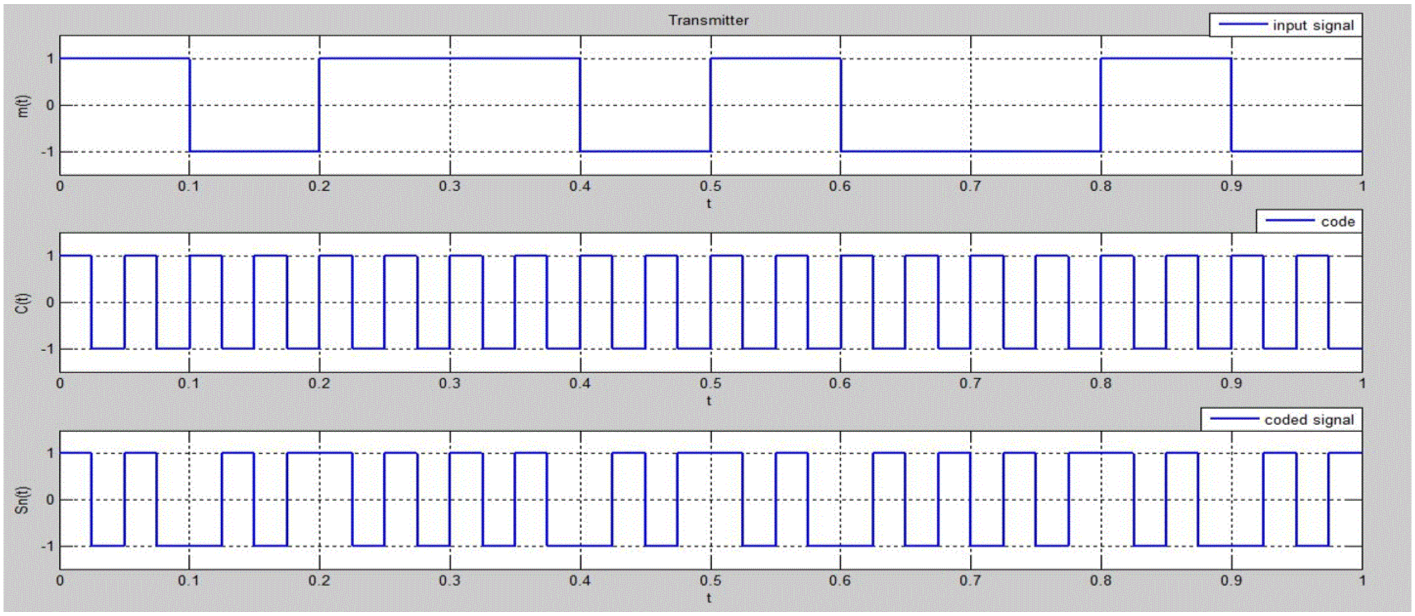
2.7 Walsh code:

One of the significant kinds of codes utilized in DS CDMA is Walsh code, which is a straight code commonly symmetrical mistake remedying codes. The significance of code originate from a great deal of good property has, it has great auto connection and awful cross relationship so it Is symmetrical, this Orthogonality is valuable property at collector to limit the impedance of one client to another clients, if the beneficiary get coded sign of client 1 and accidentally use code of client 2 to disentangle the sign the yield for this situation will be zero, on the grounds that each code for each client is symmetrical to code of different clients.



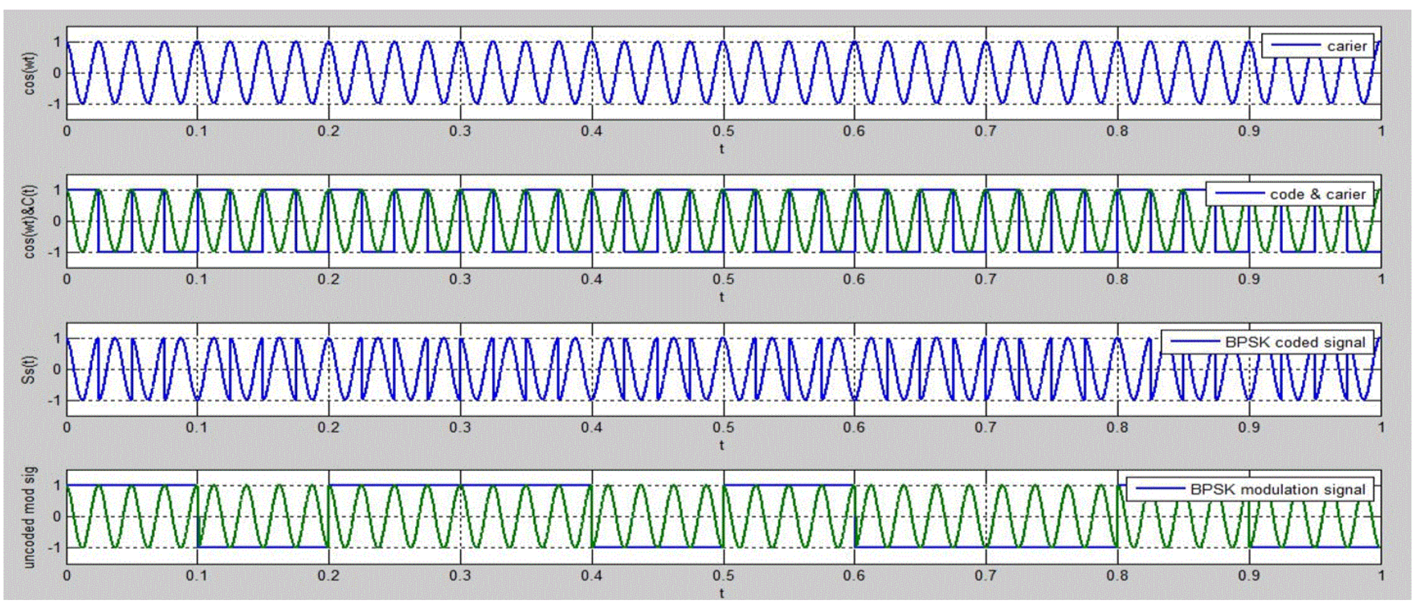
2.8 Signals shapes of MC-CDMA:

To comprehend the MS-CDMA network, how utilizing information look like what befall it after code and adjustment, how clamor consequences for it and in what capacity can get it by duplicate transmitted sign after commotion by same code utilized at transmitter and settle on choice by coordinate channel. Every one of these cases will be clear in the MATLAB diagrams demonstrated:



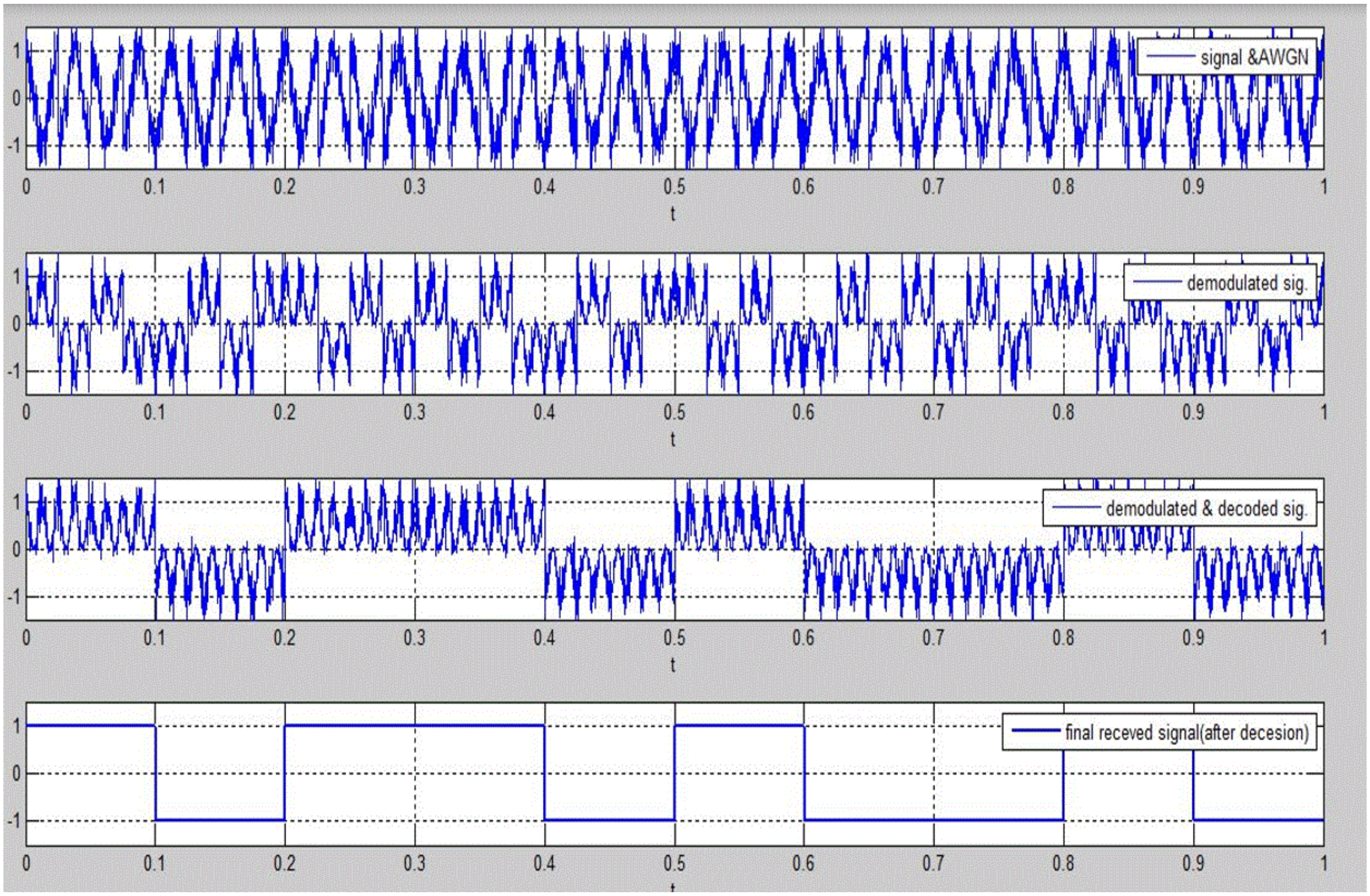
2.7Figure: Transmitted MC CDMA Signal

After modulation the signal goes through the channel,



2.8 Figure: Modulated Signal

The signal is demodulated on the antenna,



2.9 Figure: Demodulated Signal

Chapter 3

Numerical Analysis of MC-DS-CDMA

3.1 Introduction:

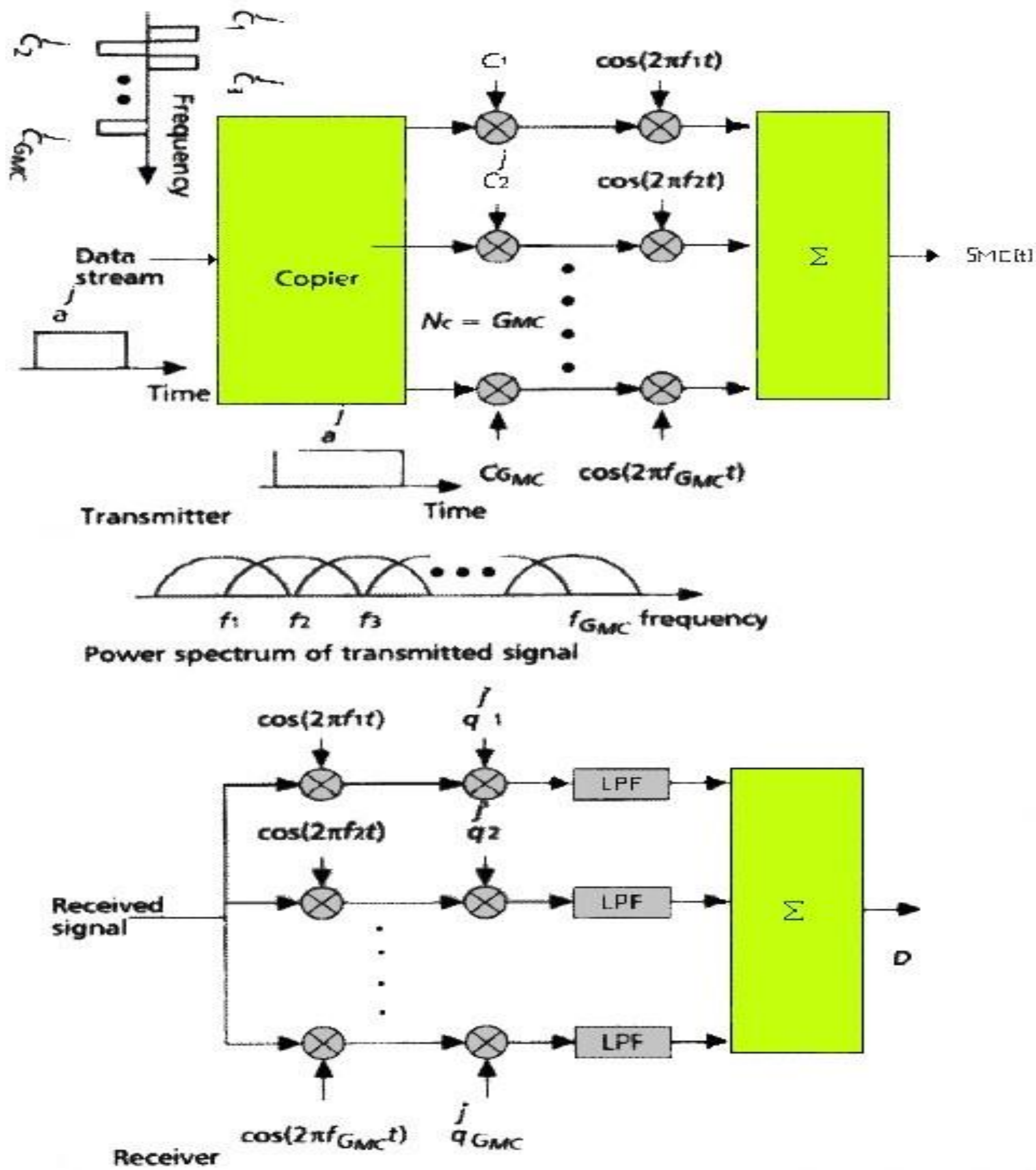
The enormous growth of wireless services (cellular telephones, wireless LAN) during the last decade gives rise to the need for a bandwidth efficient modulation technique that can reliably transmit high data rates. As multicarrier (MC) techniques combine a good bandwidth efficiency with an immunity to channel dispersion, these techniques have received considerable attention. To be able to support multiple users, the multicarrier transmission technique can be combined with a code division multiple access (CDMA) scheme.

In the literature, different combinations of the multicarrier transmission technique and CDMA are investigated in the context of high-rate communication over dispersive channels. Two techniques that make use of carriers satisfying the orthogonality condition with minimum frequency separation are multicarrier CDMA (MC-CDMA) and multicarrier direct sequence CDMA (MC-DS-CDMA). In the MC-CDMA procedure, the first information stream is first duplicated with the spreading grouping and afterward balanced on the symmetrical transporters, as the chips having a place with a similar image are adjusted on various bearers, the spreading is done in the recurrence area. In the MC-DS-CDMA strategy, the sequential to-parallel changed over information stream is duplicated with the spreading arrangement and afterward the chips having a place with a similar image adjust a similar bearer, the spreading is done in the time area. Both MC-CDMA and MC-DS-CDMA have been considered for versatile radio correspondence.

The transmitter of an advanced bandpass correspondence framework contains a transporter oscillator that up converts the information conveying baseband sign to the bandpass sign to be transmitted. At the beneficiary, the got bandpass signal is down converted utilizing a nearby oscillator. The beneficiary must make an estimation of the bearer recurrence and stage utilized at the transmitter, in light of the got sign. In view of the nearness of impedance, clamor and different unsettling influences, these estimations are not great, which brings about bearer stage mistakes. In the writing, it has been accounted for that multicarrier frameworks are delicate to certain kinds of bearer stage blunders when countless transporters is utilized. Especially bearer recurrence balance is negative for multicarrier frameworks. The impact of a little transporter recurrence balance between the bearer oscillators at the transmitter and the recipient.

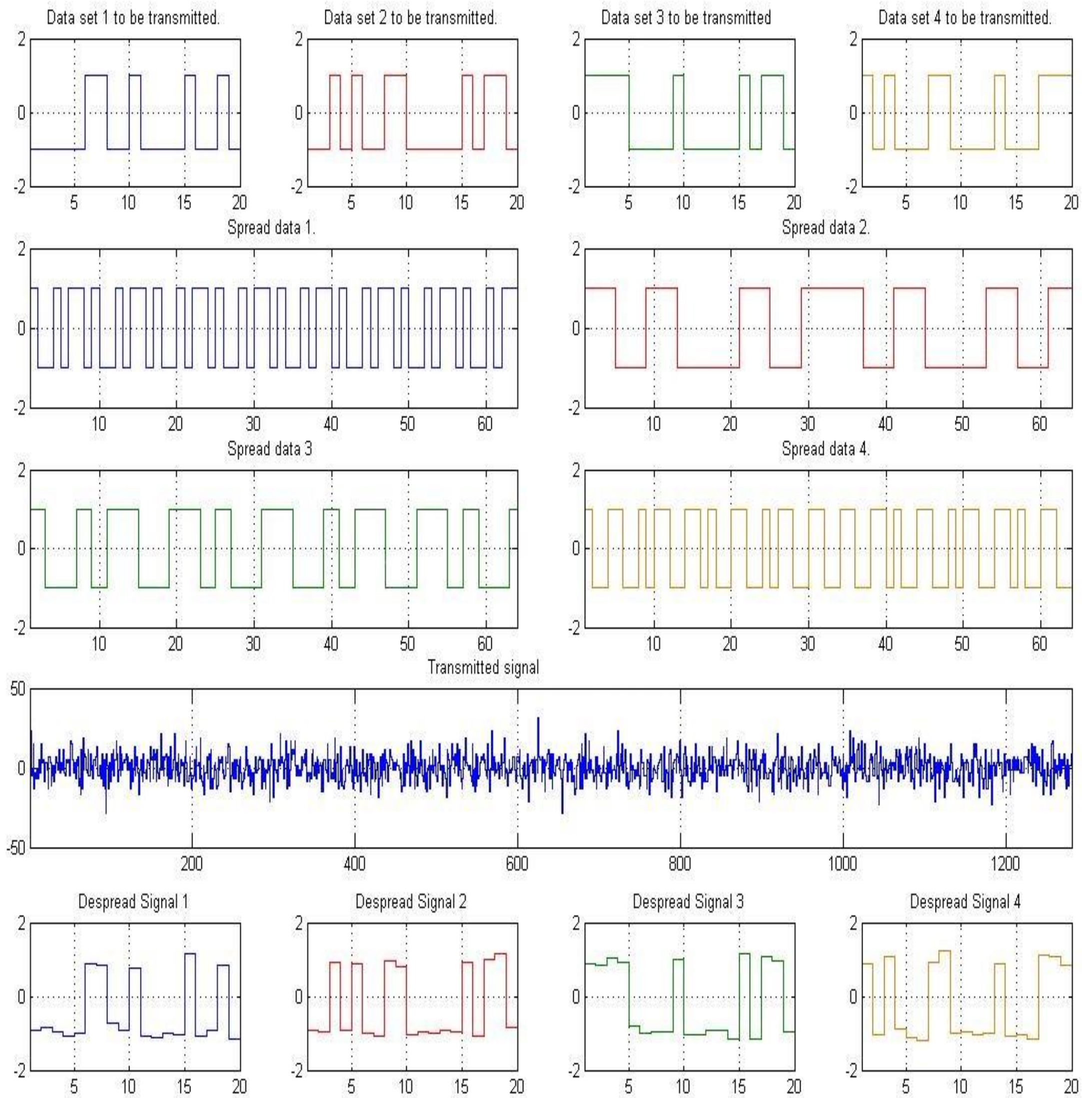
3.2 Multi Carrier Direct Sequence CDMA (MC DS CDMA):

The multicarrier DS-CDMA transmitter spreads the S/P converter data streams using a given spreading code in the time region so the consequent scope of each sub transporter can satisfy the evenness condition with the base repeat segment. This arrangement is evenly proposed for an uplink correspondence channel, considering the way that the introduction of OFDM motioning into DS-CDMA plot is suitable for the establishment of a semi synchronous channel.



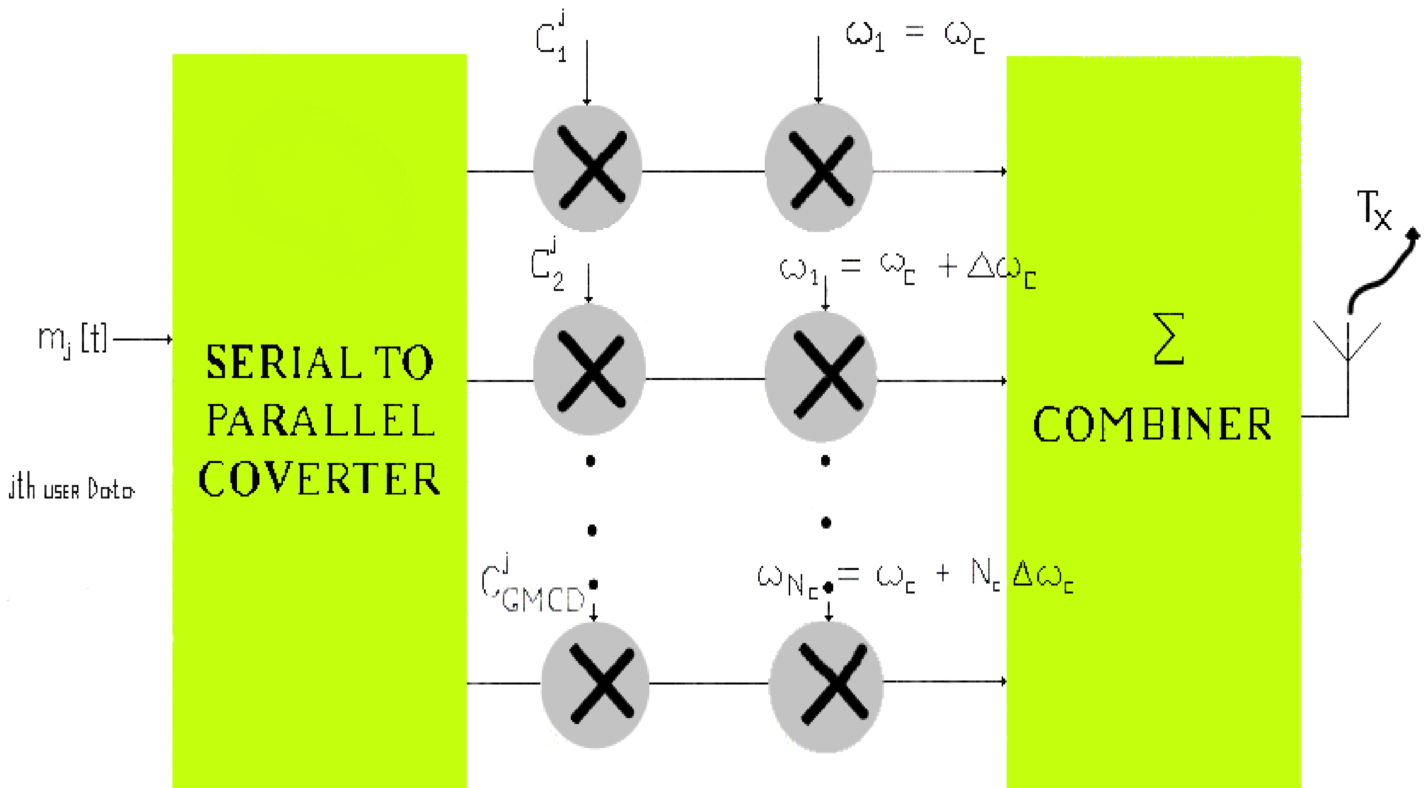
3.1 Figure: Multi Carrier Direct Sequence Code Division Multiple Access

In the figure show the MC DS-CDMA transmitted sign, separately, where demonstrates the dealing with gain, N the amount of sub bearers, and Cj(t). The spreading code of the jth customer. In a MC DS-CDMA contrive with a greater sub transporter parcel is proposed in order to yield both repeat grouped assortment improvement and confined band check camouflage. In like manner, a MC DS-CDMA plot, which transmits the game data using a couple of sub bearers, is proposed in.



3.2Figure: MC DS CDMA Spectrum

3.3 MC-DS-CDMA Analysis:



3.3Figure: MC-DS-CDMA Analysis

To find Signal to interference ratio

Here,

j =no of user

N_c= no of subcarrier

N= no of PN code per subcarrier

L=code length =N_c*N

C_j =code of j[th] user

R_b =bit error rate

$m_j(t)$=input data of jth user

b^j_n=n[th] bit of $m_j(t)$

K = Boltzman constant

T = Room temperature

B = Bandwidth

α= Amplitude distortion due fading

β= Phase distortion due fading,

b_n=±1

Input data of j[th] user=$m_j(t) = \sum_{n=-\propto}^{x} b_n^j$

Now the input data of j[th] user are converted into number of parallel data stream and each of parallel data is coded by the respective section of chips of the j[th] user code. Thus, each data is spread in time domain and spread data then is modulated by the respective sub-carrier.

Frequency spacing between channel=w_o
Frequency spacing between channel=Δw_o
The general expression of the sub-carrier is=$\sum_{k=1}^{Nc} \sqrt{2p}\cos(w_c t + k\Delta w_c t + \emptyset_k)$

Or, $S_T(t) = \sum_{k=1}^{Nc}[\sqrt{2p}\ b_{n,k}^j(\sum_{x=0}^{N=1} c_{x,k}^j) \cos(w_c t + k\Delta w_c t + \emptyset_k)]$................[16]

Multipath Rayleigh fading,

$$r(t) = \sum_{m=1}^{j}[a\sqrt{2p}\sum_{k=1}^{No}\{ b_{n,k}^m(\sum_{x=0}^{N=1} c_{x,k}^m)\cos(w_c t + k\Delta w_c t + \emptyset_k + \Theta)\}]$$ ....[17]

Receiver receives signal transmitted by all the j-th of user. Thu, the expression of the received signal is,

$$r(t) = \sum_{m=1}^{j}[a\sqrt{2p}\sum_{k=1}^{Nc}\{ b_{n,k}^m(\sum_{x=0}^{N=1} c_{x,k}^m)\cos(w_c t + k\Delta w_c t + w_c\delta + \emptyset_k + \Theta)\}]$$ ....[18]

Doppler Effect, there will be effect in carrier frequency if

$r(t) = \sum_{m=1}^{j}[a\sqrt{2p}\sum_{k=1}^{Nc}\{ b_{n,k}^{m}(\sum_{x=0}^{N=1} \ c_{x,k}^{m})\cos(w_c t + k\Delta w_c t + w_c\delta + \emptyset_k + \Theta)\}]$ + N_o……………………………………………………………………………………………………[19]

AWGN=N_O

This signal is de-modulated and then it takes the form

$r(t) = \sum_{m=1}^{j}[a\sqrt{2p}\sum_{k=1}^{Nc}\{ b_{n,k}^{m}(\sum_{x=0}^{N=1} \ c_{x,k}^{m})\cos\{(w_c + k\Delta w_c + w_c\delta)t + \emptyset_k + \Theta\}].[\sqrt{2p}\cos(w_c + k\Delta w_c)] + N_o$…………………………………………………………[20]

Decoding by using the j_{th} users code

$r(t) = a2p\sum_{m=1}^{j} \ \sum_{k=1}^{Nc}[b_{n,k}^{m} + w_c\delta)t + \emptyset_k + \Theta\} .\cos(w_c + k\Delta w_c)t] \ .(\sum_{x=0}^{N=1} \ c_{x,k}^{j}) + N_o$………………………………………………………………[21]

Rayleigh fading

$r\ (t) = ap\sum_{k=1}^{Nc}\frac{1}{2}b_{n,k}^{j}\cos(\delta w_c t + \emptyset_k + \Theta) + ap\sum_{m=1}^{j-1} \ \sum_{k=1}^{Nc} \ [b_{n,k}^{m}\left(\sum_{x=0}^{N-1} \ c_{x,k}^{m}\right)(\sum_{x=0}^{N-1} \ c_{x,k}^{j}\right)\cos(\delta w_c t + \emptyset_k + \Theta)$ …………[22]

So,

Signal =$ap\sum_{k=1}^{Nc}\frac{1}{2}b_{n,k}^{j}\cos(\delta w_c t + \emptyset_k + \Theta)$

$MAI = ap\sum_{m=1}^{j-1} \ \sum_{k=1}^{Nc} \ [b_{n,k}^{m}\left(\sum_{x=0}^{N-1} \ c_{x,k}^{m}\right)(\sum_{x=0}^{N-1} \ c_{x,k}^{j}\right)\cos(\delta w_c t + \emptyset_k + \Theta)$ ………………………………………………………………………………………………[23]

Signal power= $\frac{1}{2}a^2p^2\left(\sum_{k=1}^{Nc} \ b_{n,k}^{j}\right)^2$………………………………………………………………[24]

Noise power= $\frac{1}{2}a^2p^2[\sum_{m=1}^{j-1} \ \sum_{k=1}^{Nc} \ b_{n,k}^{m}\left(\sum_{x=0}^{N-1} \ c_{x,k}^{m}c_{x,k}^{j}\right)]^2 + KTB$……………….[25]

Signal to interference ratio,

$$SIR= \frac{Signal\ power}{Noise\ power}$$

$$SIR = \frac{\frac{1}{2}a^2 Ps^2 \left(\sum_{k=1}^{Nc} b_{n,k}^{j}\right)^2}{\frac{1}{2}a^2 Fs^2 \ \ [\sum_{m=1}^{j-1} \sum_{k=1}^{Nc} b_{n,k}^{m}\left(\sum_{x=0}^{N-1} c_{x,k}^{m} c_{x,k}^{j}\right)]^2 + KTB}$$

$$Or,\ SIR = \frac{\frac{1}{2}a^2 ps^2 Nc^2}{\frac{1}{2}a^2 Ps^2 \ \ [\sum_{m=1}^{j-1} \sum_{k=1}^{Nc} b_{n,k}^{m}\left(\sum_{x=0}^{N-1} c_{x,k}^{m} c_{x,k}^{j}\right)]^2 + KTB}$$

$$Or,\ SIR = \frac{\frac{1}{2}a^2 ps^2 Nc^2}{\frac{1}{2}a^2 Ps^2 \ \ [j-1]^2 + KTB} \text{..........} [26]$$

Conditional BER, $ber(\alpha) = 0.5erfc(\sqrt{\frac{SIR(a)}{2}})$

Un-conditional BER, $BER(\Delta f) = \int_0^\infty ber(a)p(a)da$

$$BER(\Delta f) = \sum_{t=0}^{N} ber(\alpha 1)p(\alpha 1) \text{..........} [27]$$

Chapter 4

Result and Discussion for MC CDMA

4.1Result and Discussion:

Here, we take the number of subscriber, N =16

Number of code length, L=16.

Bit rate, Rb=10000 bit per sample.

Noise power has been taken Np=10 micro watts.

We take different Signal power =12dB, 10dB, 8dB, 5dB, 0dB, -5dB, -7dB,-10dB

The equation we use here,

$T_b = 1 / R_b$……………………………………………………………………………………………………[28]

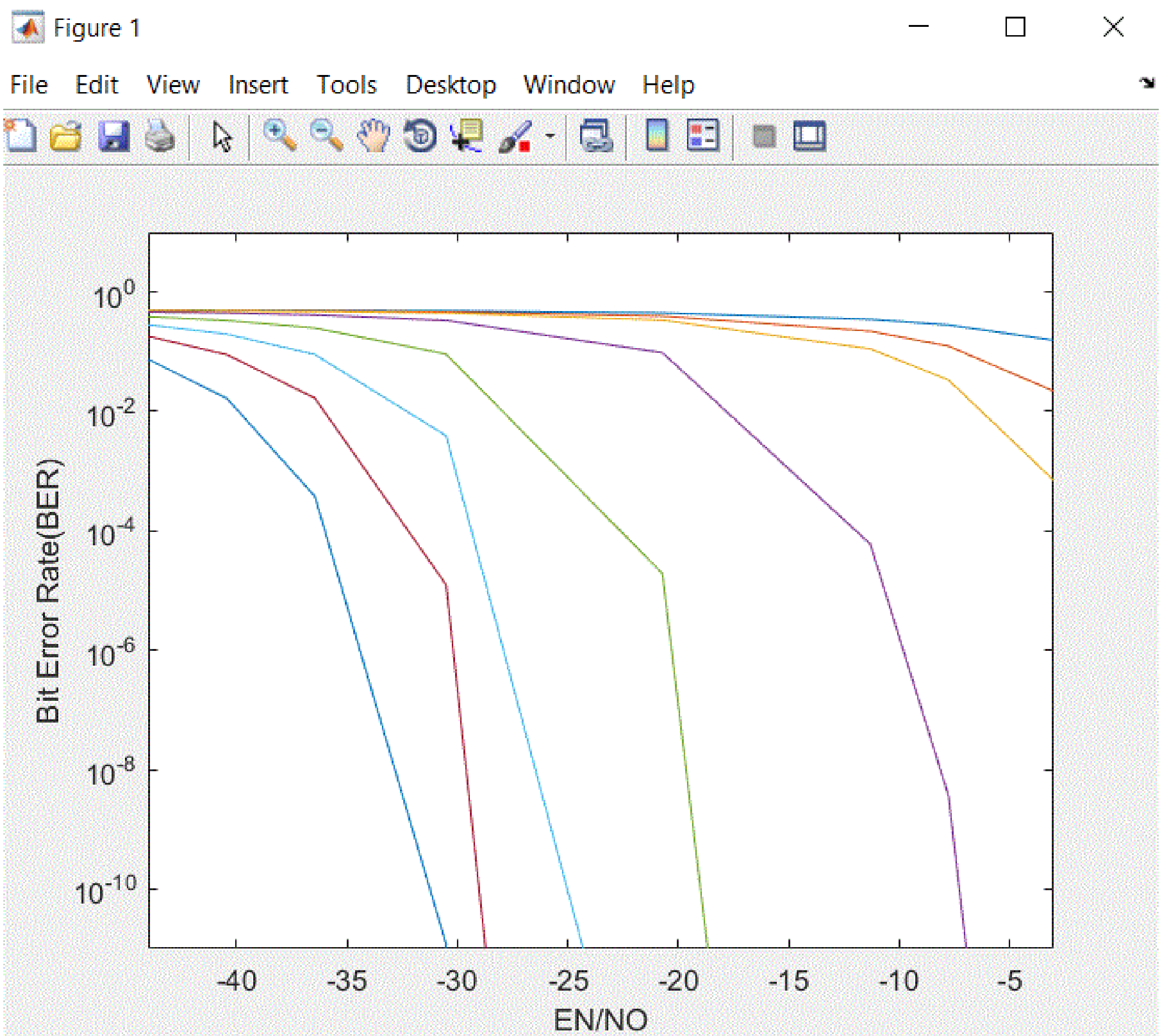
$E_b = P_o \times T_b$

$SNR = \frac{P_O}{N_O \times R_b} = \frac{P_O}{N_O \times \frac{1}{T_b}} = \frac{P_O \times T_b}{N_O} = \frac{E_b}{N_O}$……………………………………………………….[29]

$T_s = T_b / L$……………………………………………………………………………………………………[30]

Here we take P_Δ = 10% of P_o…………………………………………………………………………[31]

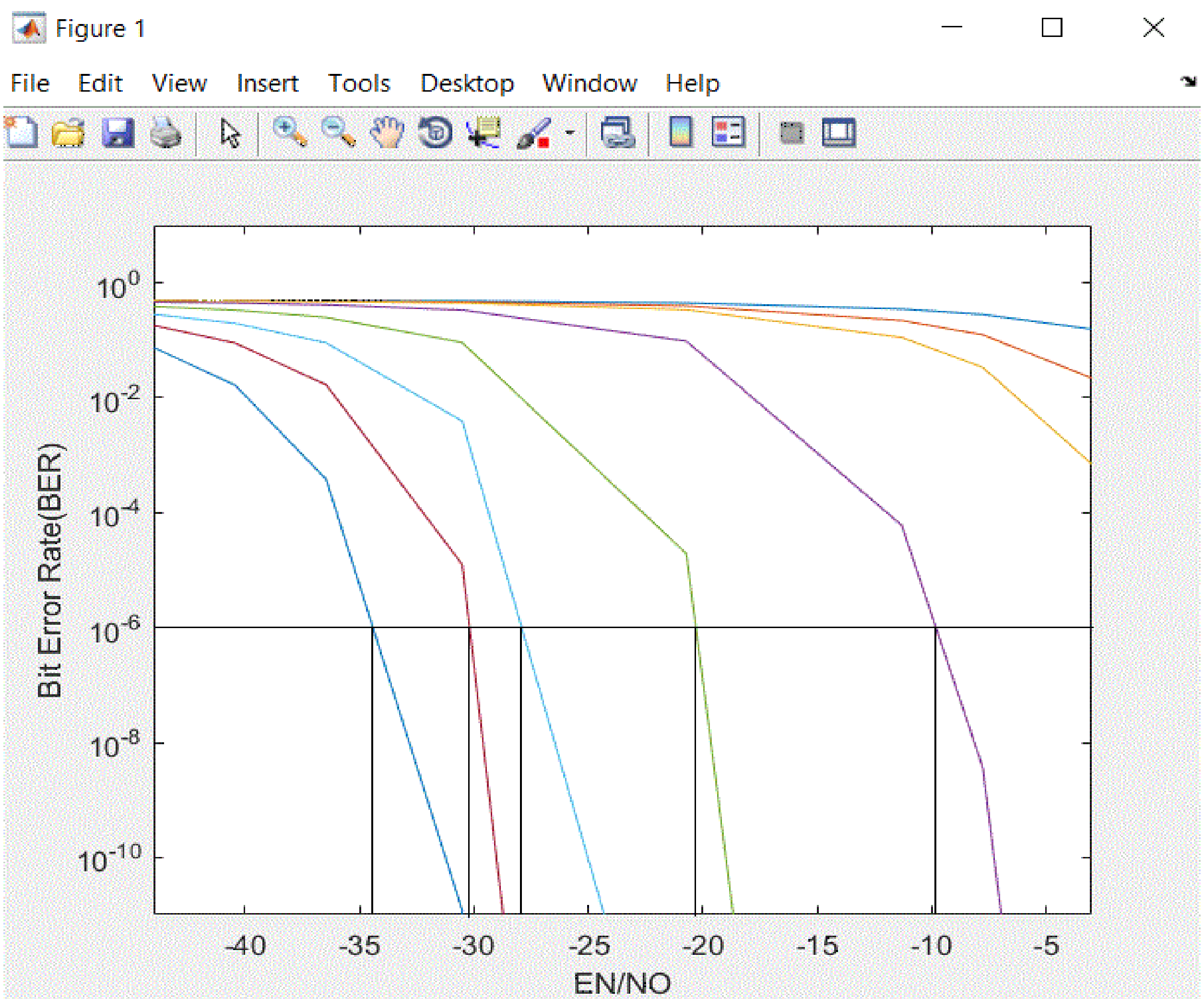
4.1.1 Plots of Bit Error Rate vs EN/No:



4.4 Figure: Plots of Bit Error Rate versus EN/No

Figure shows the Plots of Bit Error Rate versus EN/No in MC-CDMA network. This figure originates from condition .It is discovered that BER diminishes as for EN/No for a specific sign power .Signal power is high than BER decline quickly concerning EN/No. Be that as it may, in the event that sign power is exceptionally low, at that point BER diminishes gradually as for EN/No. We favor lower BER in Wireless correspondence framework and that is the reason we should utilize high sign power.

4.1.2 Plots of Bit Error Rate vs EN/No with parallel axis:

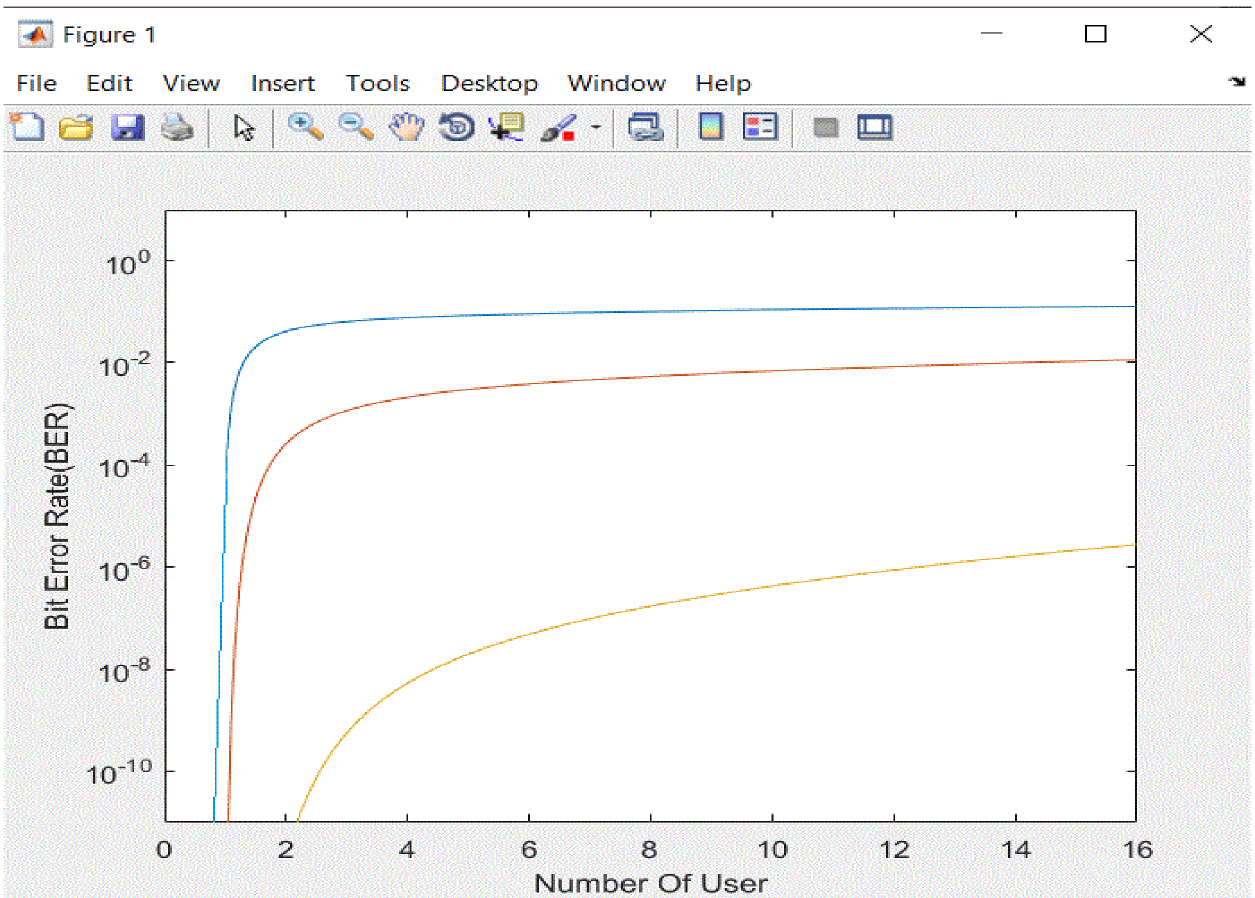


4.5Figure: Plots of Bit Error Rate vs EN/No

In figure , on the off chance that we draw a hub with parallel to EN/No from a specific BER we see that the hub meet the Po bend in 12dB, 10dB, 8dB and 5dB.By this diagram we can discover the blend of Signal power and EN/No dB for BER. From diagram we discover the blends are:

Po dB	EN/No dB
12	- 33.9 = -34 (approx.)
10	-30.1 = -30 (approx.)
8	-25.8 = - 26 (approx.)
5	-20.3 = -20(approx.)
0	-10= -10 (approx.)

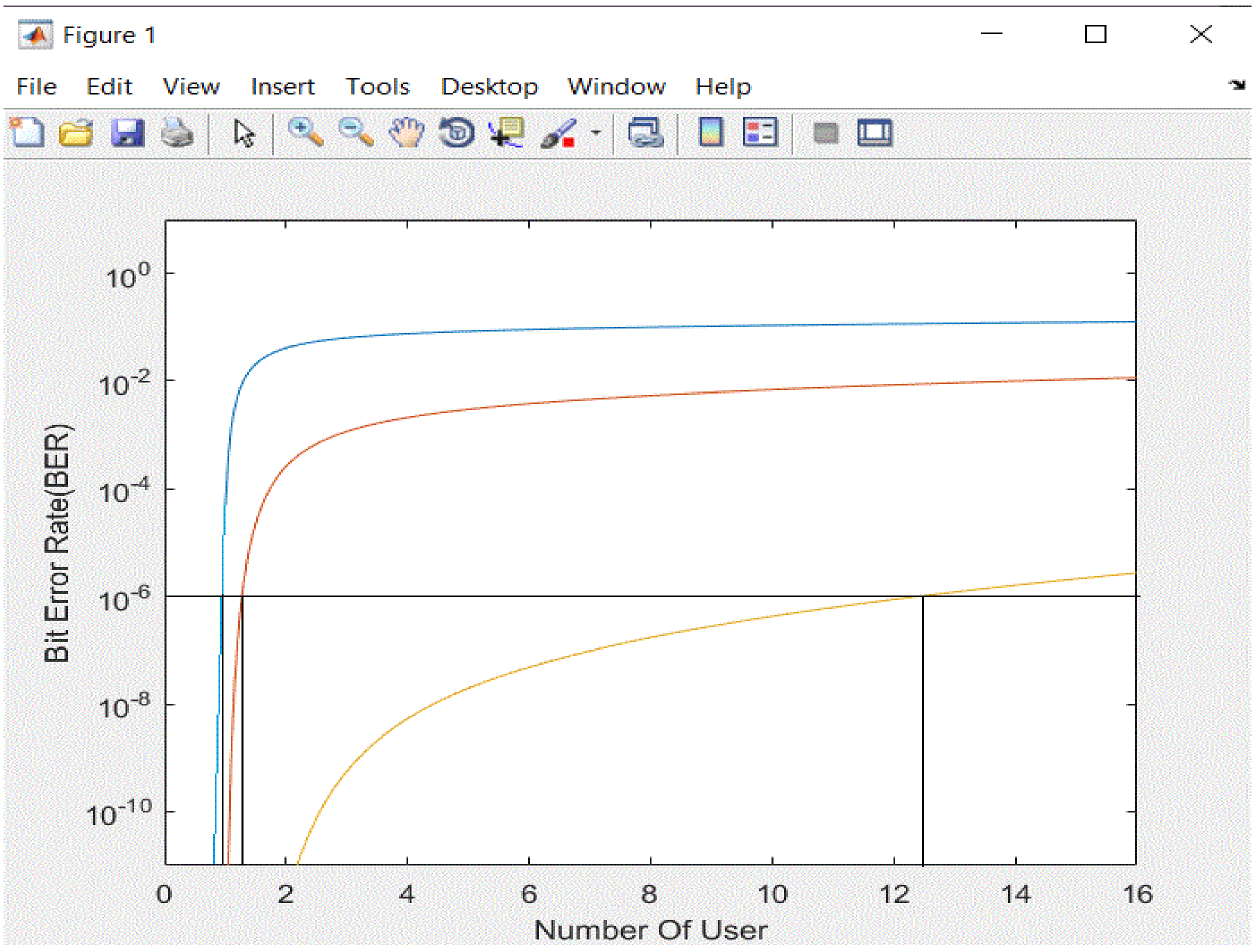
4.1.3 Plots of Bit Error Rate vs number of user:



4.6Figure: Plots of Bit Error Rate vs number of user

Figure shows the plots Bit Error Rate versus number of user in MC-CDMA nerwork. Here three distinctive code length which is 8bit, 16bit and 32 piece. The quantity of client increments and simultaneously BER additionally increments. BER isn't acknowledged in remote correspondence framework and it is fundamental to lessen higher BER. We effectively do that by expanding the quantity of chips per bit. At the point when we increment the code length the BER diminishes and we can without much of a stretch give administration increasingly number of client.

4.1.4 Plots of Bit Error Rate vs number of user with parallel axis:



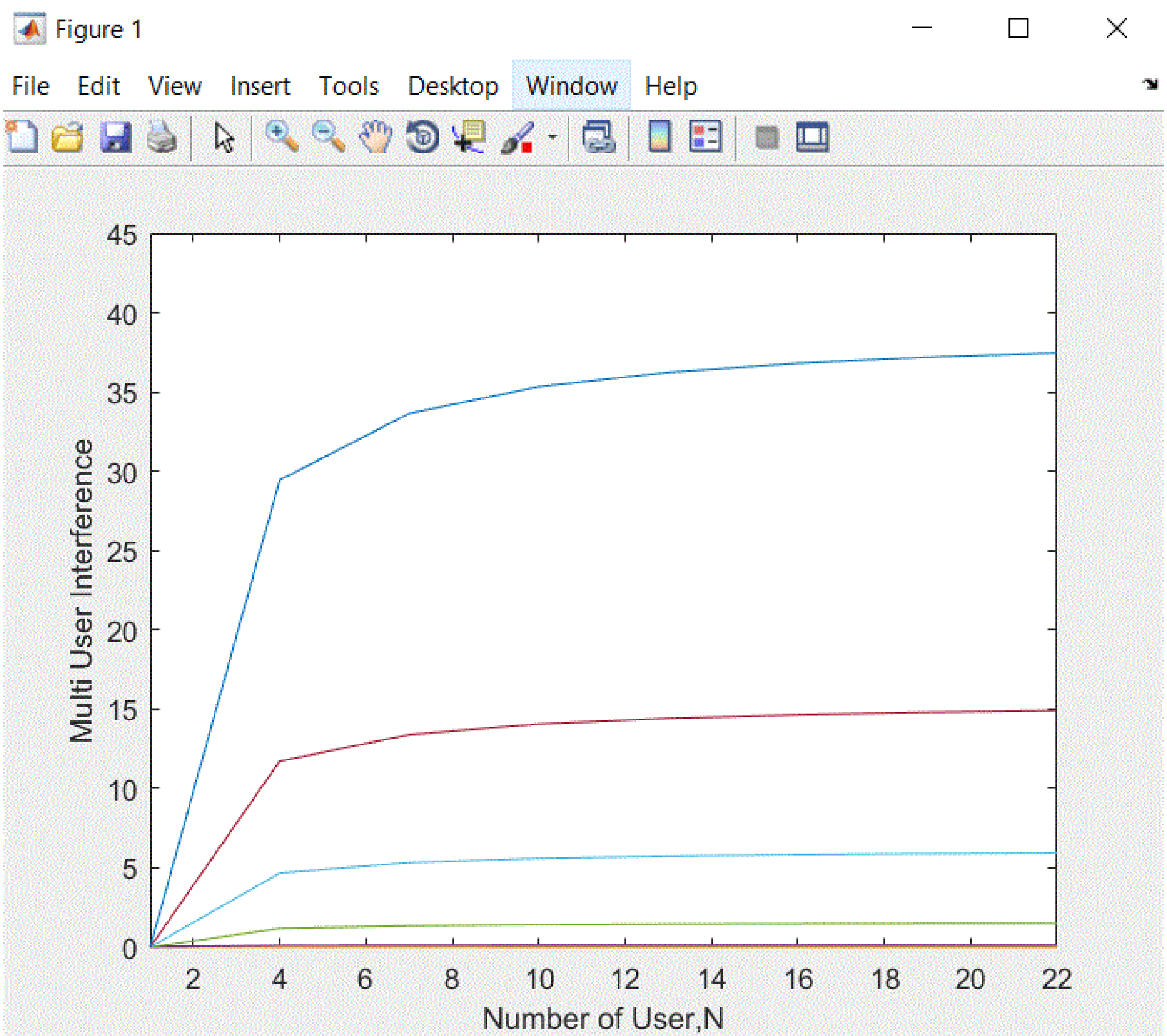
4.7Figure: Plots of Bit Error Rate vs number of user with axis

In figure in the event that we draw a axis with parallel to Number of client from a specific BER we see that the hub converge the Code length bend in L=8, L=16 and L=32By this diagram we can without much of a stretch discover the mix of Code length and Number of client for related BER. From above diagram we discover the mixes are:

Code length (L) Number of User (N)

8bit	0.8 = 1 (apprx.)
16bit	1.4 =1 (apprx.)
32bit	12.5 = 12(apprx.)

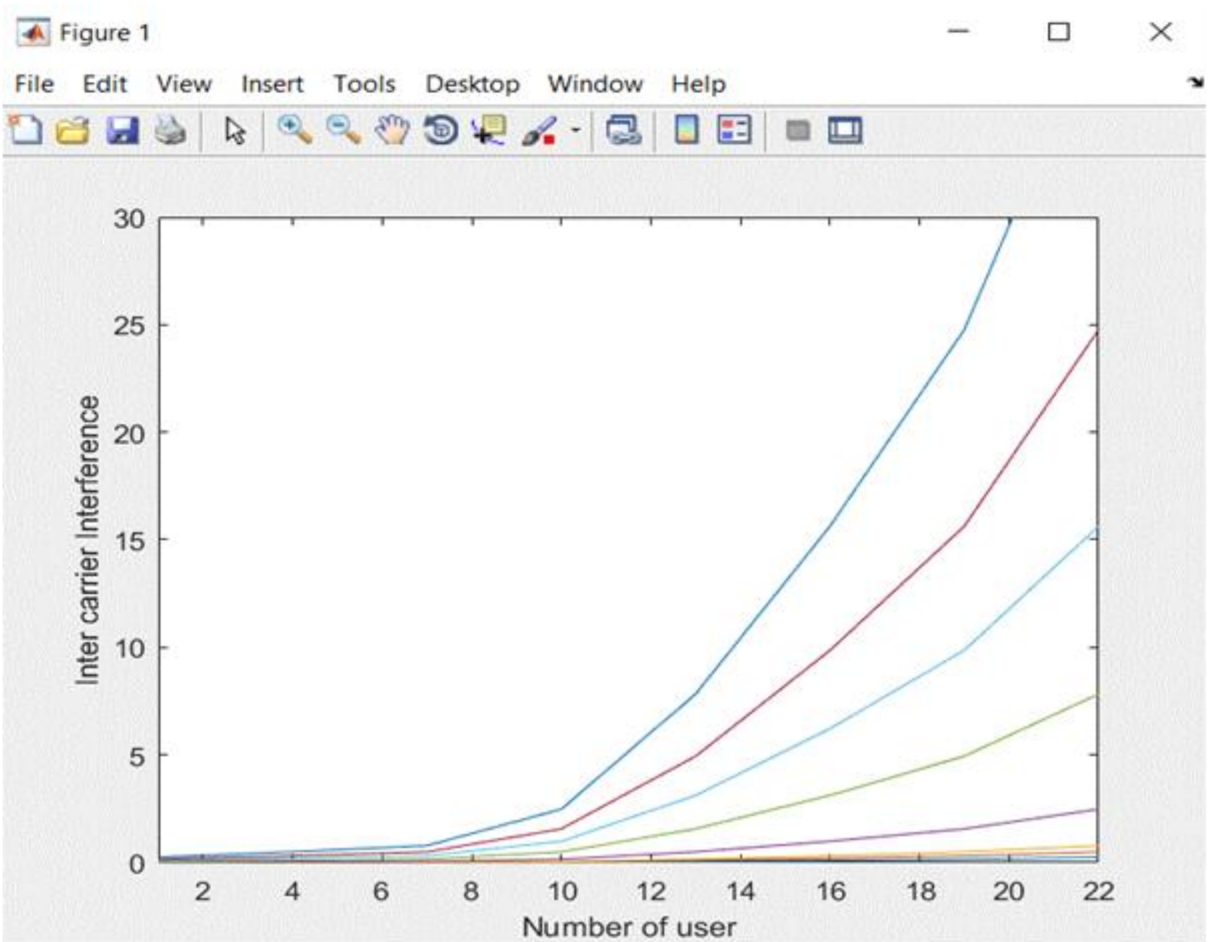
4.1.5 Plots of Multi User Interference vs Number of User:



4.1Figure: Plots of MUI VS Number of user

Figure shows the plots of MUI versus Number of User in MC-CDMA network. This figure originates from condition. We see that on the off chance that we increment the quantity of client, at that point obstruction between various client increments. The difference of the multi client obstruction relies upon the sign power. On the off chance that we increment the power, at that point the impedance increments bit by bit. For instance, in this chart fluctuation of MUI for 12dB power is exceptionally high and it is more than 30. While for low power like 5dB difference of MUI is under 2 and it is near zero for low power like - 10dB.

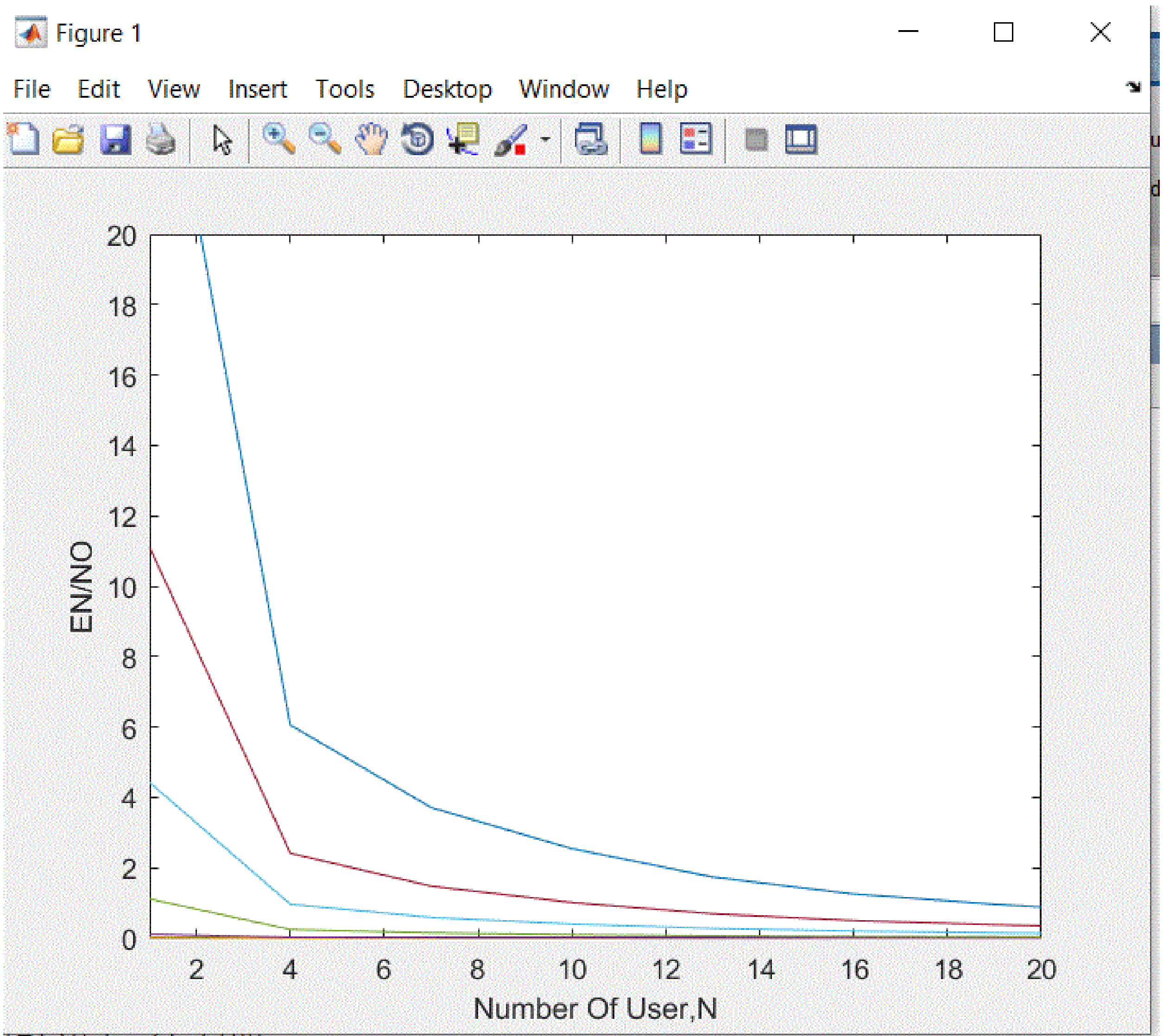
4.1.6 Plots of Inter Carrier Interference vs Number of User:



4.2 Figure: Plots of ICI vs number of user

Figure shows the plots of ICI versus number of user in MC-CDMA network. This figure originates from condition. We see that in the event that we increment the quantity of client, at that point the ICI increment. The change of ICI likewise relies upon the sign power. In the event that power is low, at that point the obstruction between the transporter is low however when we increment the power then the entomb bearer impedance likewise increment and the crosstalk between the sub transporter happens quickly.

4.1.7 Plots of EN/No vs number of user:



4.3Figure: Plots of EN/No versus number of user

Figure shows the plots of EN/No versus number of user in MC-CDMA network. This figure originates from condition. EN/No have an opposite association with no of endorser. On the off chance that we increment number of client, at that point EN/No abatements.

CHAPTER 5

Conclusion and Future

5.1 Future Work:

Further research can be carried on MC-CDMA networks thinking about the impact of blurring and recurrence counterbalance between the sub-bearers in the collector. Work can be completed to discover the improvement in BER execution utilizing Rake Receiver to battle the impact of blurring and defer spread. Works can be started to discover ideal client code length, given number of clients in a MC-CDMA networks in nearness of channel impacts.

5.2 Conclusion:

In this thesis paper we have used some basic equation to find our expected results. No new equation was determining on this thesis paper. We saw the performance for Multi-user interference and Inter carrier interference for certain number of user. If we increase the user then the MUI and ICI occurs. BER versus ratio of Energy of bit and Noise density analysis we saw that if we increase the value of EN\NO then the BER became low. In communication system we don't not prefer high BER. If BER is low then the channel transfer the signal more perfectly .We saw that by what means can the Code length impact the client limit in the networks. For a specific acknowledged BER we can without much of a stretch serve increasingly number of clients if the code length is high. The issue of MC-CDMA is Multi bearer impedance and bury transporter obstruction happen. Close far issue and Multi-way blurring another disservice of this networks. We saw in CDMA networks because of code distinction between the clients they can without much of a stretch offer a similar recurrence. That is the limit of serving client effectively can increment.

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MATLAB CODE:

MATLAB Code for MUI vs Number of user:

```
clc
clear all
close all
N=1:3:23;
N0=10^-6;
Rb=10000;
L=8;
P0dB=[-10 -7 -5 0 5 8 10 12];

  for s=1:length(P0dB)
    P0(s)=10.^(P0dB(s)./10); end
  Tb=1./Rb;
Eb=P0.*Tb;
SNR=Eb./N0;
M11=P0/N0;
M02=P0/N0^2;
M22=2*P0.^2/N0.^2;
Pdel=0.1*P0;
Ts=Tb/L;
  for j=1:length(SNR)
    for i = 1:length(N)
    sMUI(i)=sqrt(((N(i)-1)/N(i))* Ts.^2*(M22(j)-M11(j).^2));
    end
    SMUI(:,j)=sMUI;
end
Smui=(SMUI.^2)./1000;
  for k=1:length(Pdel);
    for l = 1:length(SNR);
    sICI(l)=sqrt((Pdel(k).*M02(l)).*Ts.^2);
    snoise(l)=sqrt(N(l).*(M02(k).*N0).*Ts);
    end
    SICI(:,k)=sICI;
    Snoise(:,k)=snoise;
End
format long

for y=1:length(P0);
    for z = 1:length(P0)
    EN(z)=(N0*(M11(y).^2.*Ts.^2))./(SICI(z).^2+SMUI(z).^2+Snoise(z).^2);
    end
    En(:,y)=EN;
    En1(:,y)=EN/N0;
  EndB(y)=10*log10(En1(y));
```

```
end
  Sici=(SICI.^2)./100;
  en=En1./1000;
  BER=(1./2)*erfc(sqrt(En./N0));

plot(N,Smui)
axis([1 16 0 16])
```

MATLAB Code for ICI vs Number of user:

```
Clc
clear all
close all
N=1:3:23;
N0=10^-6;
Rb=10000;
L=8;
P0dB=[-10 -7 -5 0 5 8 10 12];
  for s=1:length(P0dB)
    P0(s)=10.^(P0dB(s)./10);
end
  Tb=1./Rb;
Eb=P0.*Tb;
SNR=Eb./N0;
M11=P0/N0;
M02=P0/N0^2;
M22=2*P0.^2/N0.^2;
Pdel=0.1*P0;
Ts=Tb/L;
  for j=1:length(SNR)
    for i = 1:length(N)
    sMUI(i)=sqrt(((N(i)-1)/N(i))* Ts.^2*(M22(j)-M11(j).^2));
    end
    SMUI(:,j)=sMUI;
end
Smui=(SMUI.^2)./1000;
for k=1:length(Pdel);
    for l = 1:length(SNR);
    sICI(l)=sqrt((Pdel(k).*M02(l)).*Ts.^2);
    snoise(l)=sqrt(N(l).*(M02(k).*N0).*Ts);
    end
    SICI(:,k)=sICI;
    Snoise(:,k)=snoise;
end
  format long
  for y=1:length(P0);
    for z = 1:length(P0)
    EN(z)=(N0*(M11(y).^2.*Ts.^2))./(SICI(z).^2+SMUI(z).^2+Snoise(z).^2);
        end
    En(:,y)=EN;
    En1(:,y)=EN/N0;
  EndB(y)=10*log10(En1(y));
end
 Sici=(SICI.^2)./100;
  en=En1./1000;
```

```
  BER=(1./2)*erfc(sqrt(En./N0));
  plot(N,Sici)
axis([1 16 0 16])
```

MATLAB Code for EnNo versus Numberof user:

```
clc
clear all
close all
N=1:3:23;
N0=10^-6;
Rb=10000;
L=8;
P0dB=[-10 -7 -5 0 5 8 10 12];
  for s=1:length(P0dB)
    P0(s)=10.^(P0dB(s)./10);
end
Tb=1./Rb;
Eb=P0.*Tb;
SNR=Eb./N0;
M11=P0/N0;
M02=P0/N0^2;
M22=2*P0.^2/N0.^2;
Pdel=0.1*P0;
Ts=Tb/L;
  for j=1:length(SNR)
    for i = 1:length(N)
    sMUI(i)=sqrt(((N(i)-1)/N(i))* Ts.^2*(M22(j)-M11(j).^2));
    end
    SMUI(:,j)=sMUI;
end
Smui=(SMUI.^2)./1000;

for k=1:length(Pdel);
    for l = 1:length(SNR);
    sICI(l)=sqrt((Pdel(k).*M02(l)).*Ts.^2);
    snoise(l)=sqrt(N(l).*(M02(k).*N0).*Ts);
    end
    SICI(:,k)=sICI;
    Snoise(:,k)=snoise;
end
  format long
  for y=1:length(P0);
    for z = 1:length(P0)
    EN(z)=(N0*(M11(y).^2.*Ts.^2))./(SICI(z).^2+SMUI(z).^2+Snoise(z).^2);
    end
    En(:,y)=EN;
    En1(:,y)=EN/N0;
  EndB(y)=10*log10(En1(y));
end
  Sici=(SICI.^2)./100;
 en=En1./1000;
  BER=(1./2)*erfc(sqrt(En./N0));

plot(N,en)
axis([1 16 0 12])
```

Matlab Code for BER versus EnNo:

```
clc
clear all
close all
N=1:3:25;
N0=10^-6;
Rb=10000;
L=8;
P0dB=[-10 -7 -5 0 5 8 10 12];
for s=1:length(P0dB)
    P0(s)=10.^(P0dB(s)./10);
end
  Tb=1./Rb;
Eb=P0.*Tb;
SNR=Eb./N0;
M11=P0/N0;
M02=P0/N0^2;
M22=2*P0.^2/N0.^2;
Pdel=0.1*P0;
Ts=Tb/L;
  for j=1:length(SNR)
    for i = 1:length(N)
    sMUI(i)=sqrt(((N(i)-1)/N(i))* Ts.^2*(M22(j)-M11(j).^2));
    end
    SMUI(:,j)=sMUI;
end
Smui=(SMUI.^2)./1000;

for k=1:length(Pdel);
    for l = 1:length(SNR);
    sICI(l)=sqrt((Pdel(k).*M02(l)).*Ts.^2);
    snoise(l)=sqrt(N(l).*(M02(k).*N0).*Ts);
    end
    SICI(:,k)=sICI;
    Snoise(:,k)=snoise;
end
SICI;
format long
  for y=1:length(P0);
    for z = 1:length(P0)
        EN(z)=(N0*(M11(y).^2))./(((M22(z)-
(M11(z).^2))+M02(z).*(Pdel(z)+(N0./Ts))));
    end
    En(:,y)=EN;
    En1(:,y)=EN/N0;
  EndB(y)=10*log10(En1(y));
end
 BER=(1./2)*erfc(sqrt(En./N0));
semilogy(EndB,BER)
axis([-40 -10 10e-12 10e-0])
```

MATLAB Code for BER vs Number of user:

```
clc
clear all
close all
P0=10;
```

```
N=1:0.05:16
N0=10^-6;
Rb=10000
; Tb=1/Rb;
L=[32 16 8]
  for a=1:length(L)
    Ts(a)=Tb/L(a)
end
Eb=P0*Tb;
SNR=Eb/N0;
M11=P0/N0;
M02=P0/N0^2;
M22=2*P0.^2/N0.^2;
Pdel=0.1*P0;
  for j=1:length(L);
    for i = 1:length(N);
    sMUI(i)=sqrt(((N(i)-1)/N(i))* Ts(j)^2*(M22-M11^2));
    end
    SMUI(:,j)=sMUI;
end
for k=1:length(L);
    for l = 1:length(N);
    sICI(l)=sqrt((Pdel.*M02)*Ts(k)^2);
    snoise(l)=sqrt(N(l).*(M02*N0)*Ts(k));
    end
    SICI(:,k)=sICI;
    Snoise(:,k)=snoise;
end
  format long
 for y=1:length(L);
    for z = 1:length(N);
    EN(z)=(N0*(M11^2*Ts(y)^2))/(SICI(z)^2+SMUI(z)^2+Snoise(z)^2);
    end
 En(:,y)=EN;
    En1(:,y)=EN/N0;
end
  BER=(1/2)*erfc(sqrt(En1))
  semilogy(N,BER)
 axis([0 16 10e-12 10e-0])
```