"BER Reduction in MIMO OFDM Using Channel Estimation Techniques"

DISSERTATION

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Electronics & Communication Engineering

Specialization: Wireless Communication

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CERTIFICATE

This is to certify that **Anuj Kumar** bearing Registration no. **11008023** has completed objective formulation of Dissertation titled, **"BER Reduction in MIMO OFDM Using Channel Estimation Techniques"** under my guidance and supervision. To the best of my knowledge, the present work is the result of his original investigation and study. No part of the Dissertation has ever been submitted for any other degree at any University.

The Dissertation is fit for submission and the partial fulfillment of the conditions for the award of **Master of Technology** in Electronics and Communication Engineering.

Place: Lovely Professional University, Punjab **Miss. Nilufar yasmin**

Date: May 2014 Asst. Professor

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DECLARATION

I, **Anuj Kumar**, student of **B.Tech-M.Tech (Integrated)** bearing registration no. **11008023** under Department of **Electronics & Communication Engineering** of Lovely Professional University, Punjab, hereby declare that all the information furnished in this Dissertation report is based on my own intensive research and is genuine.

This Dissertation does not, to the best of my knowledge, contain part of my work which has been submitted for the award of my degree either of this university or any other university without proper citation.

ABSTRACT

OFDM is one of the most studied technology which support higher bit rate where data is transmitted from source to destination with very high speed.In OFDM multiple signals are multiplexed together and signals can be transferred orthogonally. In OFDM many techniques are used for data transmission and above all techniques MIMO is much efficient approach. In MIMO the signal can split into multiple signals and in the destination the multiple receiver antennas are responsible for receiving and demodulating the signal .This technique produced higher Bit error rate. In the past years many techniques had been proposed to reduce bit rate error in MIMO. In this paper, we are proposing a new technique to reduce bit rate error in OFDMs MIMO using DPSS technique .This proposed technique is a special filtering scheme where Frank Window technique has been combined with DPSS .This hybrid scheme provides a better approach towards reduction in Bit error rate.

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ABBREVATIONS

MIMO	:	Multiple Input Multiple Output
OFDM	:	Frequency division multiplexing
MCM	:	Multicarrier Modulation
ADSL	:	Asymmetric digital Subscriber
CDMA	:	Code Division Multiple Access
MC-CDMA	:	Multicarrier-CDMA
CIR	:	Channel Impulse Response
ISI	:	Inter symbol interference
SISO	:	Single Input Single Output
PSK	:	Phase shift keying
AWGN	:	Additive white Gaussian noise
PAPR	:	Peak to average power ratio
ICI	:	Inter Carrier Interference
BER	:	Bit Error Rate
MSE	:	Mean Square Error
SNR	:	Signal to Noise Ratio
FFT	:	Fast Fourier Analysis

CHAPTER 1

INTRODUCTION

1.1 Introduction of wireless communication

Wireless communication is used to the transfer of Data information from source to destination and there is no physical connection between them. Wireless technologies use the EM wireless telecommunication system, such as radio. Distances may be decreased with the help of radio waves, some of distances in meters for control television system or also for space radio communication systems. A more distances of kilometer in million can be required .It includes various types of stationary, mobile, and portable applications system, having two-way radios system, telephones and wireless networking system. Other examples of applications of wireless radio system having Global positioning system units, door garage openers, wireless mice, headsets and keyboards, earphones, RF Receivers, , broadcast television , satellite television and cordless telephones. For achieving wireless communications, it consists of the use of light, electric fields, sound waves, magnetic [1]

1.1.1 Block diagram of a wireless communication system

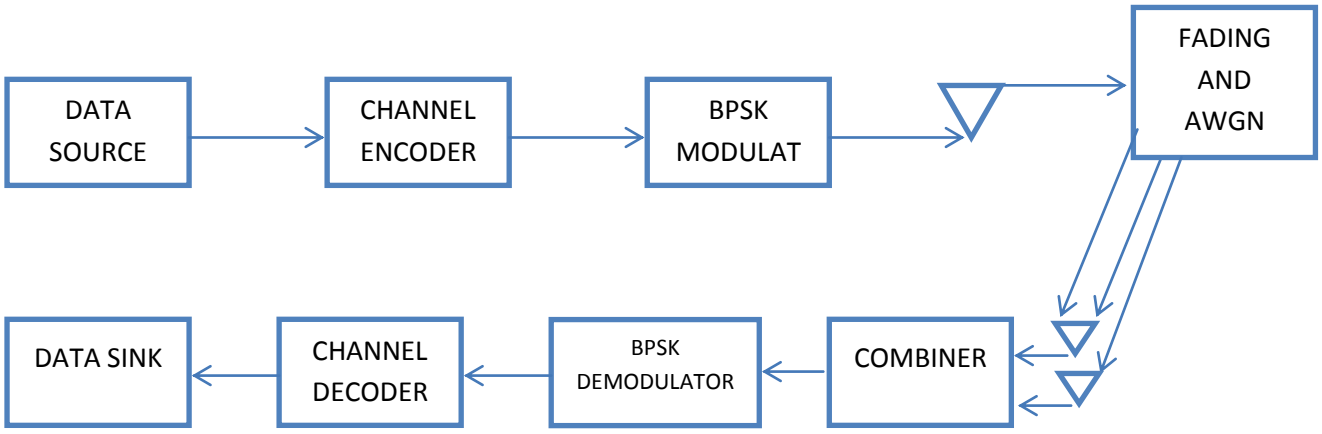

Fig 1.1 Block diagram of a wireless communication system [1]

1.2 OFDM+MIMO

Orthogonal frequency-division multiplexing (**OFDM**) is a multi-carrier modulation technique which is used for encoding the digital data on multiple sub carrier frequencies. Where the sub carriers are orthogonal to each other. OFDM has generally developed for digital communication. OFDM has developed into a popular scheme for wideband digital communication.OFDM used in audio broadcasting system and digital television system, Broadband DSL internet access, wireless networks systems, and 4G mobile.[1]

1.2.1 MIMO

In wireless radio communication, MIMO(multiple input multiple output) use the multiple transmitting and receiving antennas for improving the communication performance between the source and destination .

MIMO is generally used in wireless communication, because it provides a large amount of data throughput and without using additional bandwidth or increased transmitting power it also provides large dynamic range. For achieving higher the power spectral efficiency(more bits per second),it spread the same level of total transmit power over the antennas or for achieving the diversity that reduced the fading in the transmitted data signal.[1]

1.3 Why MIMO?

1.3.1 Increase Diversity

The main reason behind the use of multiple antennas is to improve the quality of service and also in the reliable communication performance. Diversity technique uses the multiple number antennas at both transmitter and receiver side For example, diversity is achieving by placing two antennas at a specific distance from each other, and due to physical environment it receives the different signals from the transmitted signal and then receiver combines the different signals in to one signal for improvement in estimating the transmitted signal.

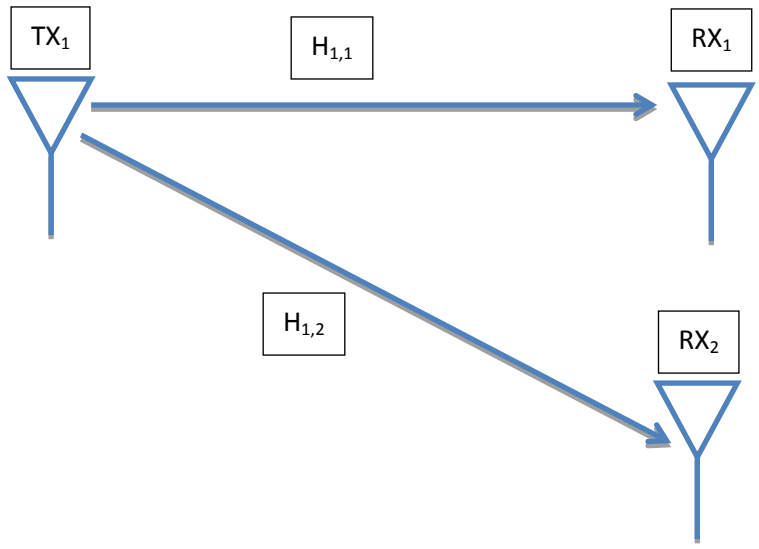

Fig 1.2 Transmitter-Receiver Antennas

Conversely, spatial diversity is achieved by using multiple transmitting antenna that are separated by some distance that has comparable result .The signal is transmitted through both transmitter 1and transmitter 2 so it has a spatial diversity. In most of cases, the transmitter send the different different signal to each antenna but rather will modify the signal so it is transmitted differently from the another antenna.[2]

1.3.2 Get Spatial

Spatial multiplexing is used for getting the higher data rate which is achieving by using the number of antennas used at transmitter and receiver side. It also increase the capacity of the transmitter and receiver antennas. The transmitted data signal is devided into two or more data signal over the multiple transmitter and receiver antennas.The small sub data signal is known as spatial data streams.[2]

1.4 Diversity in Wireless System

Wireless Communication Receiver techniques are basically Diversity based technques which gives better link performance at low complexity. Diversity techniques is used for reducing the fading in the transmitted signal due to different nature condition of channel environment in the wireless used communication system such as mobile,laptop,etc .In the diversity based communication system,Reciever receives the same number of small data signals and those small data signal is transmitted over a two or more communication channels. So the basic

concept of diversity is based on the repetition of same number of data message signal for getting the diversity. In virtual based application ,decisions are taking by the Reciver antennas and transmitter doses not know about these decisions. The data signal is transmitted over the number of different communication path. Whereas using wired technology ,diversity is achieving by using more number of wires and in case of wireless technology, this may be achieved by the antenna diversity which uses the more number of transmitting antenna it is also called as transmitter diversity or may be achieved by the two or more number of Receiver antennas which is known as Receiver diversity. Diversity combining technique is used before the transmitted signal is being processed in later. If the transmitter and receiver antennas are separated by the large distance, it is generally known as macro diversity and if they are separated from the small distance. The phased array antenna is a special case used for space time coding and for MIMO systems.

1.4.1 Maximum Ratio combining Technique

Maximum combining technique is a way of doing diversity combining that includes some useful fact

1. The transmitted signal coming from different channel is combined together.
2. The Gain of each channel environment is directly proportional to the Signal strength level and opposite relation to the square value of noise strength level.

3 For each channel envirionment, different proportional constants are added.

This technique is called as square of ratio combining and pre detection ratio combining technique.

For AWGN channel Maximum Ratio combining is the best applicable technique.

Maximum combining technique is also reconstruct its existing shape of signal.[3]

1.4.2 Equal Gain Combining Technique

Maximum Ratio combining techniques require the information about the signal to noise ratio on each different communication channel, that is very difficult to get it. Another simplified technique is introduced in which co phases signal is extracted from transmitted signal and then combined all together in to one larger signal. The working of Equal Gain combing Technique is same as Maximum Ratio combining Technique, it typically reduced the 1dB power level of the signal. Hence Equal Gain

combining Technique is reduced the complexity in their performance.

1.4.3 Selection based combining technique

SC-based Systems Only Process One of the Diversity Branches. Specifically, In Its Conventional Form, the SC combiner selects the branch with the peak SNR. In Addition since the output of SC Combiner process is equal to the signal on only one of the branches the coherent addition of the individual branch signal is not needed. Therefore, The SC Process can be preferred in conjunction with coherent and non-coherent modulations techniques since it does not need knowledge of the different signal phases on each branch.[3]

1.5 Noise and Fading in Wireless Channel

In wireless communication channel, multipath fading is deviation of the attenuation affecting a information signal over certain media. The multipath fading may vary with time, geographical location or frequency, and is often denoted as a random process. A fading communication channel is a communication channel comprising multipath fading. In wireless communication systems, multipath fading may either be due to propagation, referred to as multipath induced multipath fading, or due to shadowing problems from obstacles affecting the propagation, sometimes called to as shadow fading.[4]

1.5.1 Additive White Gaussian Noise

Additive white Gaussian noise (AWGN) is a communication channel model in which the only impairment to radio communication is a linear addition of wideband noise with a constant power spectral density (expressed as watts per hertz of bandwidth) and a Gaussian distribution of amplitude. The model does not account for multipath fading, frequency selectivity problem, channel harmful interference, nonlinearity or channel dispersion. However, it generates simple mathematical models which are useful for gaining insight into the underlying behaviour of a wireless system before these other phenomena are considered.

Wideband Gaussian noise or white noise comes and produces from many origins, such as the thermal vibrations of atoms in various conductors like, shot noise, noise produces black body radiation from the ground and other objects, and from celestial body sources such as the Sun

and moon. The AWGN communication channel is a appropriate model for many satellite and space radio communication links. It is not a good model for most terrestrial links because of multipath propagation, harmful interference, etc. However, for terrestrial path modelling, AWGN is basically used to simulate background error or noise of the communication channel under study, in addition to multipath propagation, harmful interference, ground clutter and self-induced interference that modern radio communication systems encounter in terrestrial operation.[4]

1.5.2 Nakagami fading

The Rayleigh and Rician fading modela described above fall short of describing long distance fading effects with sufficient accuracy. M.Nakagami observed this fact and then formulated a parametric gamma functuon which was inspired by his experimenta in high frequency long distance propagation. The model proposed by Nakagami uses an adaptive m parameter to descirbe the fading conditions. It is shown that fading conditions less and more severe than Rayleigh and Rician fading can also be accurately modeled by Nakagami fading. Nakagami fading model assumes that the signal that has passed through the channel will fade according to the Nakagami distribution. This means that the envelope of the channel response of Nakagami channel will be Nakagami distributed. The

PDF for this can be given by:

$$p_Z(x) = \frac{m^m x^{2m-1}}{\Omega^{\mathrm{m}}\Gamma(\mathrm{m})} e^{\frac{mx^2}{\Omega}}$$

$\Gamma(\mathrm{m})$ is gamma function and m is the shape factor with the constraint $m \geq 1/2$. Experimental and theoretical works have shown that the Nakagami distribution is the best-fit distribution for data obtained from many urban multipath radio channel.[5]

1.6 Channel Coding

In digital radio communications, a communication channel code is a broadly preferred term mostly referring to the forward error correction (FEC) code and bit interleaving in radio communication and storage where the radio communication media or storage media is viewed as a communication channel. The communication channel code is used to protect data information sent over it for storage or retrieval even in the presence of noise (errors).[6]

1.6.1 Convolutional Code

In Radio-Communication, a convolution code is a type of error-correcting code in which each m numbers of total bit information symbol to be source encoded is transformed into an n-bit communication symbol, where m/n is the code *rate* ($n \geq m$) and the linear transformation is a function of the last k data data information symbols, where k is the constraint length of the source code. Convolution codes are basically used in various radio applications in order to obtain reliable data information transfer, including digital video, radio, mobile communication, and satellite applications. These types of codes are often used in concatenation with a hard-decision code, particularly Reed Solomon code. Prior to turbo based codes, such constructions were the most efficient and less complex , coming closest to the Shannon limit.[6]

1.6.2 Reed-Solomon Code

In information coding theory, Reed–Solomon (RS) codes are of non-binary type cyclic error-correcting codes invented by Irving Reed and Solomon. They described a systematic way of building codes that could detect and correct multiple random symbol based errors. By adding t check communication symbols to the information data, an RS code can detect any combination of up to t communication symbols, and correct up to $t/2$ communication symbols. As a code, it can correct up to t known erasures, or it can detect ad correct best combinations of error and noise and erasures. Furthermore, RS codes are preferable as multiple-burst bit-error codes, since a sequence of $b + 1$ consecutive bit errors can affect at most two symbols of size b. The choice of t is up to the designer of the code, and may be selected within wide limits.

In Reed–Solomon coding, symbols are viewed as coefficients of a primitive polynomial $p(x)$ over a finite field of math. The original idea was to create n code communication symbols from k number of source communication symbols by oversampling $p(x)$ at $n > k$ distinct points, and use various interpolation techniques at the communication receiver to detect the original information. That is not how RS codes are required today.

1.6.3 MIMO

MIMO (Multiple Input Multiple Output) in contrast to traditional communication systems takes advantages of multipath signals. Rather to apply different techniques to deal with multipath radio signals MIMO puts multipath communication signals to work. This is done by sending and receiving more than one information data signal in the same spectrum band at the same time by using multiple antennas [1]. Wireless channels are multipath communication fading channels; causing Inter symbol interference, ISI occurs when a transmission harmful interferes with itself and communication receiver cannot decode the signal correctly.

For multipath signals travelling through different paths have their independent effect imposed by the communication channel. Signal parameters on which multipath channel have effect are independent path gain (or loss), independent path frequency offset, independent path phase shift (change in angle), independent path time delay. To remove ISI from the signal, many kinds of equalizers can be used. Different techniques are used to handle the changes made by the channel; receiver requires knowledge over CIR (Channel Impulse Response) to combat with the received signal for recovering the transmitted signal. CIR is provided by the separate channel estimator. Usually channel estimation is based on the known sequence of bits, which is unique for a certain transmitter and is repeated in every transmission burst. Which enables the channel estimator to estimate CIR for each burst separately by using the known transmitted signal and the corresponding received signal.

In communication model the SISO/MIMO communication channel model represents the physical medium which connects the transmitter and receiver units. This medium can be wired line or a wireless based connection. All received communication waveforms will be more or less corrupted due to different- different factors that are noise from various electronics devices, non-linear distortion, interference from other transmissions, atmospheric noise, fading, etc. At the communication receiver side of the digital communication system, there are one or more receiving antennas. Each communication antenna receives a weighted and possibly filtered addition of the different transmitted waveforms. The digital demodulator processes these data signals and produces a binary stream again. In MIMO communication systems, the d-modulator/equalizer module reconstructs the transmitted signals from the weighted sums of signals transmitted by different antennas, using the estimate provided by

the communication channel estimator and communication received signal. The d-modulated signals are fed to the decoder. The decoder analyzes the basic structure of the detected bit waveform and tries to correct errors. Finally, the corrected bits are passed to the communication decoder that is used to recover the destination data signal or digital data input signal. The modules are data modulator, communication channel, data demodulator and for most of the part on the communication channel estimator for communication systems. Choice of different Modulation scheme is greatly influenced by the radio environment in which communication system is supposed to work. PSK (phase shift keying) is used for modulating the basic distributed data stream over orthogonal multiple sub carriers. To achieve high performance the communication receiver needs to know the impact of communication channel, the problem is how to extract this data information in an efficient manner. Usually known symbols are multiplexed into the information data sequence in order to estimate the communication channel. From these communication symbols, all communication channel attenuations are estimated. The behaviour of communication channel is described by its impulse response and also there is some additive white noise which is often data modulated as AWGN [1] representing different different disturbances in the communication system. The requirement for high capacity in cellular areas and wireless local area networks has grown in a rapidly manner during the last years. In particular, the need for wireless Internet and multimedia type applications need an increase in data information throughput with orders of magnitude compared to information data rates made available by today's communication technology. One basic technological breakthrough that will mainly increase the throughput of communication systems in multipath fading environments is the use of various antennas at the transmitters and receivers in the communication system[1]. A system with multiple transmit and receive antennas is often called a multiple-input multiple-output (MIMO) system.

The using of MIMO communication systems has need of multiple transmit and receive antennas and hence multiple radio frequency chains which enhancement in the cost and complexity of the communication system. To conquer this major problem, a fewer RF chains can be required at the transmitter along with a new method which called antenna selection technique. This reduces the complexity of the communication system while maintaining the advantages of various MIMO systems. These antenna selection schemes work well for the MIMO channels. However, most practically occurring mobile cellular channels exhibit fading correlation due to the lack of spacing between various antennas, or to the existence of small

angular spread. In such communication channels, Hybrid Selection schemes performs considerably worse than full-complexity schemes because the data signals at the different antenna exhibit correlation, which make decreases the gain of the antenna selection.

1.6.4 The Performance Benefits:

The performance benefits available as a result of using the MIMO wireless Systems are largely due to multiplexing gain, communication diversity gain, array gain, and harmful interference reduction. Each of these is briefly described below with assumption of having MT and MR numbers of transmit and receive communication antennas respectively.

Spatial multiplexing gain: Spatial multiplexing technique is the simultaneous transmission of multiple data signals from transmitter to the receiver, with both equipped with more than one antenna. Consequently, MIMO system is able to offer a linear capacity proportional to the minimum number of either the transmit antennas or the receive antennas, in comparison with Systems employing single antenna at one or both end of the links, for no extra power or bandwidth .This gain which is commonly referred to as multiplexing gain, is possible if the propagation communication channel exhibits rich scattering process. The communication receiver takes advantage of differences different in the spatial signatures induced into the multiplexed signals by the MIMO channels to separate the different-different streams of information data transmitted, thereby realizing a high capacity gain.

Diversity gain, as earlier described in the previous section, communication diversity is a powerful communication technique to reduce the effect of multipath fading in wireless communication links where data signal power fluctuates very randomly. Diversity gain is achieved by communication transmitting the data signal over multiple, independently multiple fading paths in time, frequency. Antenna diversity is however preferred over time-frequency communication diversity because it does not involve expenditure of either transmission time. Provided that the M -MT-R links comprising the MIMO channels fade independently and the transmitted data signal is suitably constructed, the MIMO communication Systems‟ communication receiver can combine the arriving signals such that the resultant data signal exhibits considerably reduced amplitude variability in comparison to a SISO link. Consequently, M Mth T R order of diversity will be achieved.

Array gain: MIMO communication Systems increases antenna gain by beam forming. The gain can be achieved both at the transmitter and the receiver, but depends on the number of

transmit and receive antennas. Besides, transmit/receive array gain requires channel knowledge in the transmitter and receiver respectively .

harmful Interference reduction: The differentiation between the spatial signatures of the signal and co-channel data signals, when multiple antennas are used, can be employed to reduce interference which occurs due to frequency reuse in wireless communication channels. Just like the case with array method for MIMO Systems, harmful interference reduction also requires knowledge of the data signal's channel. Harmful Interference reduction allows aggressive frequency reuse and thereby increases the communication system capacity [2].n multiplexing is a frequency division multiplexing design utilized as a digital multi carrier modulation. A huge figure of closely spaced orthogonal sub carriers is used to carry information data. The information data is divided interested in a number of parallel streams of channels one for each sub carriers. Each sub carrier is then modulated with a conventional modulation process at a low; maintain total information data rates related to the conventional single carrier data modulation schemes in the same bandwidth. Frequency Division Multiplexing is a kind of data signal multiplexing which involves turning over non overlapping frequency or communication channels to different data signals or to each user of a communication medium. A guard band is left between each of these communication channels to ensure. Orthogonal Frequency Division Multiplexing is a special form of multicarrier modulation which is mainly well-matched for broadcast over a dispersive communication channel. Here the different sub carriers are orthogonal to each, that is, they are totally independent of one another. This is basically achieved by placing the sub carrier exactly at the nulls in the modulation power spectra of each other. A simple communication system consists of a transmitter end which transmits the data and a receiver end at which the data is received successfully. Usually there received data is not the same as the data sent. Because of the noise present in the medium the data signal gets affected is observed in the data signal. Various modulation techniques are under taken in order to ensure that the data signal sent is safely available at the information data receiver end. Frequency Division multiplexing is a type of information data signal multiplexing which involves frequency ranges or communication channels to different signals or to each one use of a communication medium. A guard band is missing between each of these communication channels to make sure that the data signal of one communication channel does not related with the data signal from an adjacent signal one. Orthogonal Frequency Division Multiplexing is a special form of modulation which is particularly suited for data transmission over a dispersive communication channel. Here the different carriers are orthogonal to each other, that is, they are totally independent of one another. This is achieved by placing the carrier exactly at the nulls in the modulation spectra of each other. By working with OFDM in domain of frequency the modulated

4-PSK data symbols are fed onto the orthogonal sub-carriers. But transfer of signal over a channel is only possible in its time-domain. For which we implement IDFT which converts the OFDM signal in from frequency domain to time domain. IDFT being a linear transformation can be easily applied to the system and DFT can be applied at the receiver end to regain the original data in frequency at the receiver end. Since the basis of Fourier transform is orthogonal in manner we can implement to get the time domain equivalent of the OFDM signal from its frequency components. Usually, in practice despite of DFT and IDFT we implement fast fourier transformation for an N-input signal system because of the lower hardware complexity of the system. In OFDM the transmit signals are constructed in such a way that the frequency spectra of the individual sub channels are allowed to overlap thereby utilising the natural spectrum.

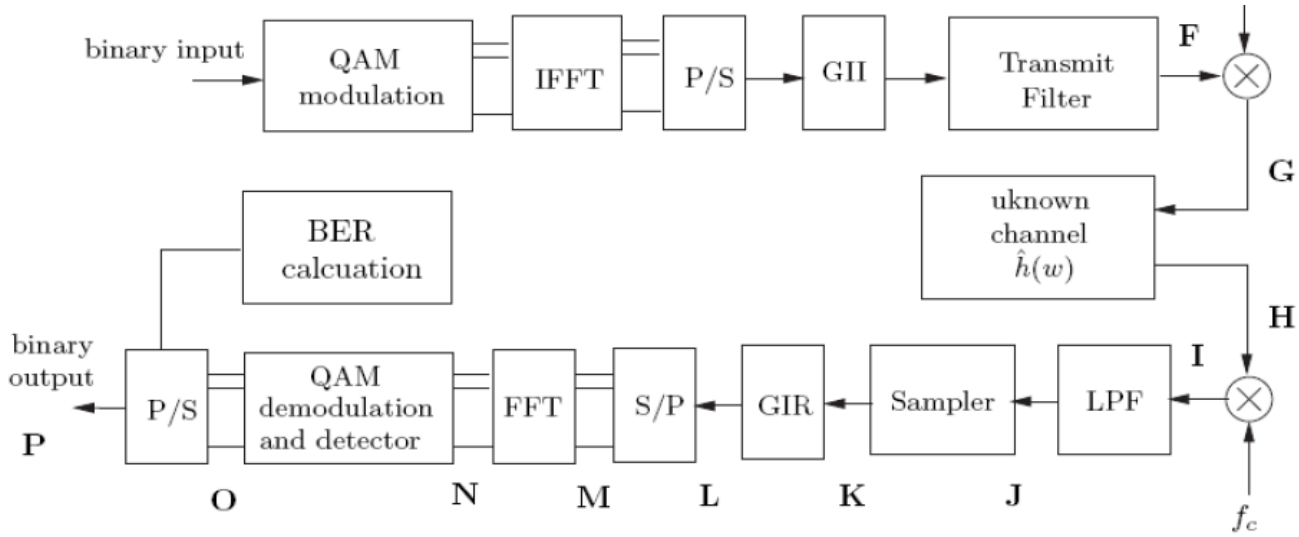

Fig. 1.3 Block diagram of OFDM System

1.6.5 OFDM System

a) Modulation

Modulation is the process in which the signal frequency is changed in to higher order for covering the larger communication distance. This is to be done because of the Received signal is reconstructed again its original shape state. In OFDM System a large data rate information signal is divided in to small sub data signal which are orthogonal to each small data sub signal .This is done by optimum QAM modulation process.

b) IFFT/IDFT

After modulation process, DFT/IFFT is applied on the band pass signal for reducing the mathematical complexity from the band pass signal

c) Parallel to serial converter

After IFFT/DFT ,the output of the DFT/IFFT block operation the signal is processed by using the parallel to serial converter for combining into one data signal.

d) Cyclic Prefix(CP)

And then for removing the inter symbol interference in the modulated signal we add the cyclic prefix.it also help us to recover the data information from the received noisy signal at the receiver side.

1.6.6 Communication channel

Communication channel is the propagation media through which the signal is propagated or transferred at the receiver side. communication channel contain the its response called as noise and communication channel noise is harmful for our data message signal which results in adding abrupt change in the data message signal. And this abrupt change is called as the signal distortion and results in decreasing in the amplitude of the data message signal.

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1.6.7 Demodulation

Demodulation is the process of recovering the data signal from its Received modulated data signal at the receiver side.

In the demodulation process several steps are followed ,

Received data signal is giving to the low pass filter(LPF) which removes the higher frequency component in the signal(removing the carrier frequency in the transmitted signal) and then cyclic prefix is removed from the output of LPF (Low pass filter). And after that removed CP signal is giving to the parallel to serial converter which converts the signal in to many sub signal .Then we Apply the FFT/DFT operation on each sub data signal.

After that demodulation process is performed on the data signal which reconstruct the original data signal. this block is called as Demodulator. And then we apply the BER formula for calculating the Bit error rate and we also calculates the signal to noise ratio with the help of base band data signal and received data signal at the receiver side.

1.6.8 Advantages and disadvantages of an OFDM System

a) Advantages

An OFDM system having some advantages . These advantages are given as

1. There is a reduction in delay spread due to increase in symbol duration.
2. With the help of adding guard band of interval in the transmitted signal ,it eliminates the effect of the Inter symbol interference as well as the inter carrier effect.
3. By using orthogonal small sub carriers OFDM system removes the effect of frequency selective fading in the signal.
4. The spectral efficiency of the spectrum of OFDM system is optimum desirable .and it is done by the IDFT/IFF operation.

b) Disadvantages of An OFDM System

The Disadvantages of an OFDM system are giving below

1. OFDM systems are directly affected by the Doppler frequency or shifts due to higher data rate transmission which results the inter channel interference.
2. In OFDM system there is a large number of small sub carrier with varying strength of the signal which results in the higher peak to average power ratio in the OFDM system which affects the efficiency of Radio frequency amplifier.

1.6.9 Basic Block diagram of An OFDM Transmitter and Receiver

a)Basic Block diagram of An OFDM Transmitter

The main working principle of OFDM Transmitter is to divide the data signal into N small sub data signal or data stream which reduced the data rate by the factor of 1/N. Then each sub data signal is modulated at different different sub carrier and after modulation process each modulated sub transmitted data signal is summed up in to one signal which is having the same data signal rate as of single data.

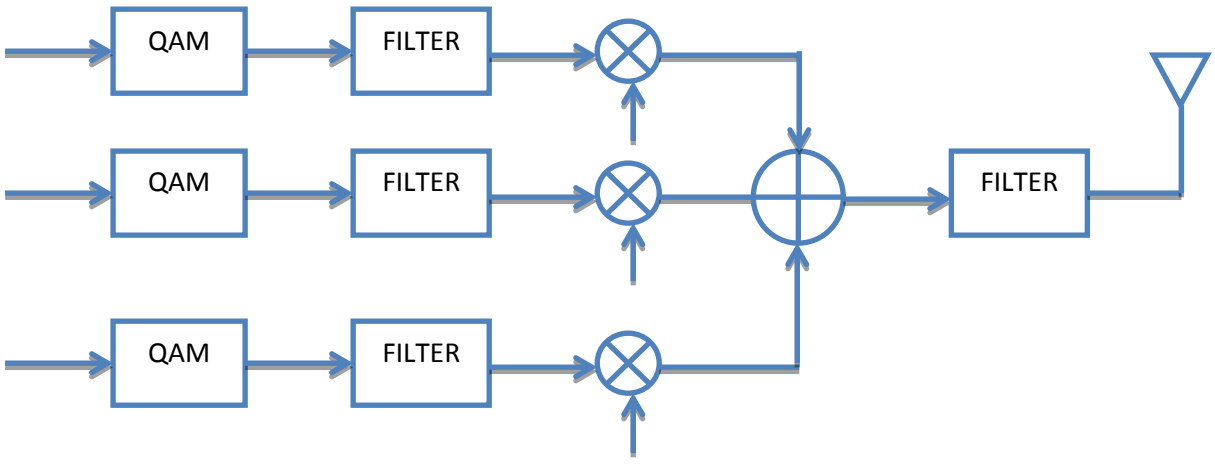

Fig. 1.4 Block Diagram of OFDM Transmitter

b)Block diagram of An OFDM Reciever

The block diagram of OFDM Receiver is shown below in fig 1.5.

At the receiver side a transmitted data signal is received by the receiving antenna. N number of low pass filter is used to extract the sub carrier from the transmitted wide band signal for demodulation purpose.

This OFDM Receiver is not affected by the Inter symbol interference which is occurred due to the multipath signal propagation. Hence each of sub channels is experienced by the flat fading which eliminates the complexity of the equalizer at the receiver side

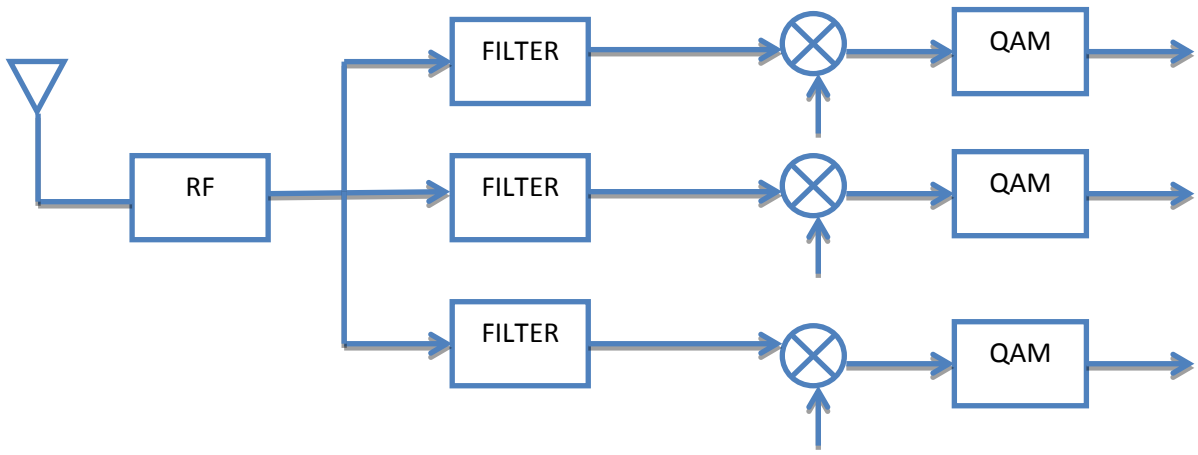

Fig. 1.5 Block Diagram of OFDM Receiver

1.7 Property of Wireless channel

OFDM is especially used for the wireless channel. In this section we study the important property of wireless channel and also study about the advantages and disadvantages using OFDM System in the wireless channel .The important properties is used in wireless channel are given below

a)Multipath Propagation

Electromagnetic waves(EM wave) are travelled from this wireless medium Hence wireless medium is harmful for the transmitted signal . wireless media or channel may contain the large height of building ,terrain and mountains which directly affects our transmitted signal because there is no clear line of sight of the receiver. Hence the data signal is travelled through the different different multiple path and at the receiver side a multiple number of data signal is reached .

Therefore this introduces the effect of inter symbol interference which gives the higher bit error rate(BER).The delay introduced by the wireless channel is directly proportional to the Inter symbol interference effect that is measured by the single data pulse using the root mean square delay spread fact.

Hence inter symbol interference effect decreases the data rate. Data rate may be increased by reducing the symbol time period at the transmitter side but this technique increase the inter symbol interference effect due to the root mean square delay spread hence this method require more complex designed equalizer at the receiver side.

As the wireless channel media results in the root mean square delay spread (which fade the data signal strength) and this can not be changed manually. So the system may be designed with concern of these wireless media.
So we use the technique of multicarrier in which the wide bandwidth is converted into small small narrow bandwidth signal .

And then these narrow bandwidth signals are sent in the parallelly where each data signal is modulated at different sub carrier frequency . Hence these transmitted data signal are not affected by the root mean square delay spread.

Guard interval insertion

For reducing the effect of the inter symbol interference, a number guard interval(Ng) is inserted between each OFDM symbol before transmitting the data signal to the receiver hence the transmitted signal is having the symbol time of interval (N+Ng) per OFDM symbol .

The length of the guard interval is more than the expected time delay spread (i.e introduced by the channel) hence it gives method of elimination of the inter symbol interference at the receiver side.

At the receiver side N number of OFDM Sysmbol is selected from the transmitted signal interval(i.e N+Ng) for maximal power and the rest OFDM symbols are eliminated. After this for reconstructing its original state FFT/DFT is applied on the demodulated data signal

1.8 OFDM System

OFDM provides the high quality performance in terms of the speed of data transmitting to reach at the receiver side because of fact that OFDM system converts the data information signal into small small sub data signal and then modulated at different sub carrier frequency.This carrier technique is known as multi carrier modulation techniques.

Hence Multicarrier modulation technique is better than the single carrier modulation technique due OFDM gives the high data rate. And multicarrier modulation technique is used in ultra-high frequency and in analysis of microwave spectrum.

In OFDM system the data signal is transmitted with the help of different small sub carrier in which each of the sub carrier having different frequency and each of multiple small sub carrier frequency are orthogonal to each other which help us to reduce the effect of inter symbol interference.

This technique is very useful in wired as well as wireless communication media and these communication medias are Asymmetric digital subcarrier line and IEEE802.EEE wireless communication standard.
OFDM technique also provide the higher capacity coverage than the code division multiple access technique which is possible to access wireless channel for 4^{th} genearation(4G) standard.

This scheme also gives the higher efficiency and reliability in transmitting the data signal over the communication radio channel and also in multipath channel environment[3]

Multiple input and multiple output in OFDM System transmits the data signal through the multiple number of transmitter antennas and receives the multiple input transmitted data signal by using the multiple number of receiving antennas. This technique provides high quality diversity to get the optimum data rate.

This diversity process is known as spatial multiplexing for desirable data transmission rate by the factor corresponding to number of using transmitting antennas. Hence all sub data signal uses the same band of frequency with orthogonally separated each other and provides the higher spectral efficiency.

OFDM technique sent the data signal with the help of multiple number of sub carriers. Where the sub carrier is orthogonal to each other by selecting the carrier frequency and the time synchronization which results that there is no interference between them. Without taking any notice the sub carriers are orthogonal to each other in the frequency domain. The OFDM name is made from the existence that the data signal is transmitted through multiple sub carriers and each of these carriers are orthogonal to each other. Hence OFDM technique has been studied and find that multicarrier technique is better than the single carrier technique. OFDM System is generally used because it gives the higher spectral efficiency and it require the low complex equalization for slow fading communication channels.OFDM technique provide multiple access to user at the same time and OFDM technology also provides time and frequency multiple access to each user at the same time. Another extended version of The OFDM technique is multiple carrier CDMA technique (MC-CDMA) which is the hybrid technique of OFDM technique and the CDMA technique [3] Hence The frequency division multiplexing is effectively use the multiple sub carrier technique. A large number of sub data carriers is used to carry the data information .and the data signal is converted in to small sub data signal for each sub carrier and then each of data sub stream is modulated using optimum modulation scheme. Hence it gives the data rate is higher than single carrier techniques in using the same band of frequency. FDM techniques which consists of enabling the use of Frequency Division Multiplexing is a form of signal multiplexing which involves turning non overlapping in frequency domain for each user.

1.9 Analysis OF ICI

Inter carrier interference (ICI) is a drawback of an OFDM System which is occurred due the Doppler effects in the channel or because of difference in its local oscillator frequency between the source and the destination and this is also known as carrier offset.

Hence this carrier offset problem may remove the orthogonality of the sub carrier signal and the signals are transmitted with help of each sub each sub carrier may not independent to each other which gives the inter carrier interference problem

Many of research papers have given the technique for fighting with the Inter carrier interference (ICI) which is generally occurred in the OFDM.

Many of technique is describes method for removing the inter carrier interference problem such as method of frequency domain equalization ,windowing method and the self cancellation schemes have been used.

ICI may be removed by using the statistically method to estimate and for cancelling the inter carrier interference.

In addition, statistical approaches have also been explored to estimate and cancel ICI.

Some of the methods which removes the nature of the inter carrier interference are given below

One method is used for removing the inter carrier interference effects with the help of repetition data. Repetition data is transmitted on each sub carriers signal such that inter carrier interference may be removed at the receiver side.

In the second method Inter carrier interference is removed by using the window technique and IC can be removed with the help of the Maximum likelihood estimation method or may be cancelled by using Kalman filter

OFDM is also keeping some sort of Drawbacks.one of the drawback is carrier offset problem which is occurred due to the effect of Doppler shift and

Doppler frequency is introduced in the data signal due to the relative motion of the transmitter and receiver or may be introduced by the different local oscillator frequency at the source and destination stages.

Hence the introduced factor is helping to modulate parameter of the carrier offset which is given below in the figure

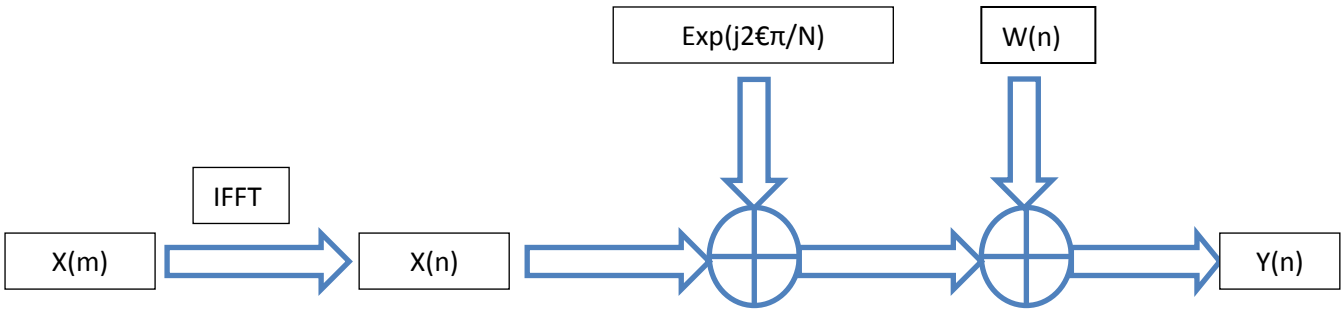

Fig 1.6 Block diagram of Frequency offset

The received signal is expressed as given below

$$y(p) = x(p)\ e^{\frac{j2\Pi p3\varepsilon / N}{N}} + n(w)$$

Where e represents the normalized carrier frequency offset and n(w) denotes the additive white Gaussian noise.

A new technique has been introduced for removing inter carrier interference in the received data signal in which the data signal is modulated with the help of group of sub carrier with known coefficients as the inter carrier interference is generated in this group that cancel out each other. This technique is known as self ICI cancellation.

1.10 OFDM Transmission Advantages and disadvantages

OFDM Systems have some advantages and disadvantages of their Transmission .These are given as below

a) OFDM System Transmission advantages

The advantages of OFDM System Transmission are

1 OFDM System has a potential to interact with multipath communication channel delay spread.

2. In the slow time channel variation, OFDM increases the capacity of the system with the help of the data rate per sub small carrier corresponding to the SNR.

3. OFDM mainly gives the good performance against the narrow co channel interference.

4. OFDM Systems is generally used for broadcasting System based applications.

5. OFDM technique gives the frequency diversity method by increasing the small sub carriers over the entire spectrum of the OFDM System.

6. Compared with the single carrier system ,OFDM System has a potential to remove the frequency selective fading with the help of the narrowband small data sub carrier .

7. OFDM System especially designed for reducing the effect of inter symbol interference by using the guard interval insertion between each OFDM Symbols

8. OFDM also uses the channel coding and interweaver that has a potential to remove the effect of the frequency selective fading for decreasing the SER(Symbol error rate)

9. Equalization technique is very simpler to implement it for extracting original data signal from the received data signal.

10. OFDM System has very less complex in terms of the computationally operation because it uses FFT operation at the receiver side for demodulation purpose.

11. There is no need of estimating the wireless communication media because OFDM uses the different modulation methods as compared with the single carrier system.

12. OFDM Systems can be less affected by the time synchronization as compared with the single carrier Systems.

13. OFDM has also the capability to fight with the co channel interference and the channel noise.

b) Disadvantages of OFDM System Transmission

OFDM System has also some disadvantages .these disadvantages are given below

1.OFDM System gives the higher inter carrier interference because of the higher date rate of the OFDM .it also introduce the error in the phase of the transmitting data signal in the channel environment.

2. OFDM gives the burst performance in terms of peak to average power ratio. Hence OFDM systems reduce the efficiency of Radio frequency amplifier.

3. OFDM system need a high power radio frequency amplifier for noise added in the amplitude of the transmitting data signal through the multipath channel.

4. OFDM technique provides the higher carrier offset problem in the transmitted data signal compared with the single carrier system.

Chapter 2

LITERATURE REVIEW

MIMO OFDM is having the major contribution to perform the reliable data transmission over a channel. But even though such kind of network communication suffers from many problems like ICI, PAPR etc. Lot of work is done by many researchers to resolve these different kinds of problems by using these approaches. In this section, the work done by earlier researchers is discussed

J.Armstrong "Analysis of New and Existing Methods of Reducing Intercarrier Interference Due to Carrier Frequency Offset in OFDM"(1999)

This paper gives the various methods for removing the effect of the inter carrier interference in the OFDM System based applications which is occurred due to the carrier offset problem.

In this paper inter carrier interference is removed by using the method of ICI self cancellation. This paper present the study of ICI self cancellation and the window technique is used for removing the effect of the inter carrier interference in the received data signal at the receiver side.

The author of this paper tell us that inter carrier interference(ICI) is occurred due to the channel time variation and this ICI problem may be removed by assuming the channel is Equivalent linear time varying model.

The author presents the ICI self cancellation method for reducing the higher order frequency offsets in the OFDM System.

This technique (ICI cancellation) is effectively worked for reducing the inter carrier interference. Hence this technique gives the higher performance of the OFDM System in terms of ICI and Bit error rate(BER).

In this ICI self cancellation method data signal is transmitted with the help of the group of subcarriers

The main drawback of this technique is less complex signal values are sent per OFDM symbol period .[4]

Zhao and S. Hangman " Inter carrier Interference Self-Cancellation Scheme for OFDM Mobile Communication Systems" (2001)

This paper also deals with the method of carrier ICI self cancellation for removing the effect of the interference in the OFDM System.

This paper gives the good channel impulse response that has been analysed by the theoretical simulation result.

This technique also gives the high quality performance in the case of Doppler effect by using multipath channel environment.

The author of this paper describes that this ICI self cancellation technique gives the better ICI performance and the BER than the existing OFDM System.

Hence This proposed can be easily implemented and there is no need of equalization for reducing the effect of inter carrier interference(ICI).[5]

Heung-Gyoon Ryu, Yingshan Li, and Jin-Soo Park: "An Improved ICI Reduction Method in OFDM Communication System" (2005)

This paper also analysed the performance of the OFDM System in terms ICI reduction. Inter carrier interference is occurred due to the phase error in the transmitted data signal. This phase error increase the carrier interference between the each OFDM Symbols.

The performance of the OFDM System is analysed and compare with the help of the data signal conversion and channel coding used in the OFDM System in terms of ICI and Bit error rate. This method is known as data conjugate technique .

In this data conjugate technique inter carrier inter carrier interference and channel impulse response which is occurred by the Phase error are being measured and after that the performance of the OFDM System is compared with existing used technique based OFDM application.

And in this paper the author find that ICI , channel impulse response and also CPE is zero for flat fading channel environment.

This paper also describes the performance of OFDM System in terms of Bit error rate. Phase error introduced in the transmitting data signal is affected the actual working performance of the OFDM System.

The performance of the OFDM System is efficiently increased by using the ICI self cancellation method. This method gives the better BER Performance than the previous techniques. Data conjugate technique gives more better BER improvement performance in the OFDM System.

Hence the performance of the data conjugate technique gives the best simulation results in terms of peak to average power ratio and Bit error rate .

This paper uses the channel coding and the data conversion technique and gives the high quality transmission performance of the OFDM System.[6]

Jianqiang He," MMSE Interference Suppression in MIMO Frequency Selective and Time-Varying Fading Channels"(2008)

The work is been implemented under the fading channels. The work includes the analysis on ICI and the ISI . A joint analysis is performed on these two type of interference and the kalman filter is been implemented in this paper.

The work also includes the use of feedback equalizer to perform the noise reduction along with channel estimation for uncertain interference over the channel. The time and frequency based analysis is used by the researcher [7].

In **year 2008 Jia TU** has performed a work on **Turbo Equalization based on a New Kalman Filter for OFDM over Doubly-Selective Channels**

The approach is implemented for the fading channel and the analysis is performed for both the time and frequency selective data transmission.

In this work a turbo equilizer is suggested with kalman filter. The Kalman filter performed the statistical analysis and the ICI reduction is being performed by using the turbo equalizer.

The results are being performed in terms of time delay and complexity analysis. [8]

One more work is been performed **by Hussin Hijazi "OFDM High Speed Channel Complex Gains Estimation Using Kalman Filter and QR-Detector" (2008)**

The author has implemented a delay based analysis for multipath channel under the fading constraint.
The kalman filter analysis is performed to noise estimation and to perform the ICI reduction the QR decomposition is been implemented. The simulation results are based on High Doppler spreads. [9]

In **Shih-Kang Wang" Pilot-Aided Channel Estimation Methods for ICI Reduction in Mobile OFDM Systems"(2009)**

The ICI reduction algorithm includes the channel impulse response. In this paper the effect of the inter carrier interference is removed with the help of channel impulse response over the entire range of the communication channel environment .

The work is analysed under the frequency and time domain approach. To perform the noise analysis kalman filter was used by the researcher. The BER ratio analysis is used to present the final results. [10]

To remove the unknown noise over the OFDM system a work is presented by **Jaechan Lim "Inter-Carrier Interference Estimation in OFDM Systems With Unknown Noise Distributions"**(**2009**)

The ICI estimation and reduction performed by using two main approaches called Kalman Filter approach and the Carrier frequency offset.

The statistical approach was presented by the author to perform the analysis estimation as well as noise reduction over the channel. [11]

In **same year 2009** another work is performed by **P. Beinschob " MIMO-OFDM equaliser for spatial multiplexing transmission modes"**

In this work the author introduce the equalizer technique ,by using this technique data rate of the OFDM System is decided by the Equalizer.
The performance analysis is done under the pulse noise and the results are presented in terms of reduced error bits.

The work is performed on linear and non linear data transmission over the network. The work includes the maximum likelihood algorithm to resolve the communication error. [12]

Kandarpa kumar has performed some work on "**MIMO Channel Modeling using Temporal Artificial Neural Network (ANN) Architectures"(2010)**

The researcher adept the statistical nature of the network and combined it with neural to perform the channel estimation as well as the symbol recovery.

The work is based on multi layered perceptron architecture. In this work author consider the indoor network and modal the channel under slow fading conditions[13].

Another Kalman filter based work was presented by **Hussein Hijazi in 2010 " Joint Data QR-Detection and Kalman Estimation for OFDM Time-Varying Rayleigh Channel Complex Gains"**

The work is based on the time domain and the delay analysis is been performed for multipath communication. The polynomial coefficient is been used for the channel matrix is been presented with ICI for QR decomposition for the channel matrix [14]

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Jin Whan Kang," Adaptive Modulation and Coding for MIMO-OFDM Systems using LMS Channel Prediction and CQI Table Adaptation" (2011)

In this auther performed a work on channel prediction based on CQI table adaptation.

The work include the effective modulation and coding scheme for channel prediction in OFDM system. The channel is been analyze based on statistical parameters and the different filters are being implemented to perform the noise analysis.

In this work the analysis is performed on channel quality and based on this an adaptive utilization table is generated to get the verification about the channel limits under different parameters. These parameters includes the error reduction under wiener filter. [15]

Mitalee Agrawal is on "BER analysis for MIMO OFDM System for AWGN & Rayleigh Fading Channel " (2011)

The work is performed for fading channel and Gaussian noise. The author analyze the work under different modulation schemes.

The paper is aimed at analyzing the BER performance of the MIMO (Multi-Input Multi-Output) OFDM system for Gaussian channel, Fading Channel along with simulation channel using different modulation technique.

The work is performed for BER analysis. The work is extended in two ways first to analyze the BER and perform ICI reduction respectively second Kalman filter is implemented for BER analysis. [16]

CHAPTER 3

PRESENT WORK

In this chapter we discussed about the problem formulation in section 3.1 ,Research Methodology and Research work are discussed in section 3.3 ,section 3.4 respectively

3.1 Problem formulation

MIMO OFDM is one of a emerging communication scheme that provide efficient communication with Multi-Carrier Modulation. Many wireless networks have adapted the same communication approach.

The performance of OFDM System is affected by multipath channel environment in terms of Bit error rate and ICI problems.

Hence Inter carrier interference has a capability to introduce the distortion in the Received data signal which increase the bit error .

In this base paper author has presented scheme in which ICI self cancellation technique is used for mitigating the inter carrier interference and the Bit error rate.

In this paper a window technique is used for mitigating the Bit error and the effect of the Inter carrier interference in the received data signal at the receiver side.

Receiver Windowing block Diagram has been proposed by the author as shown below.

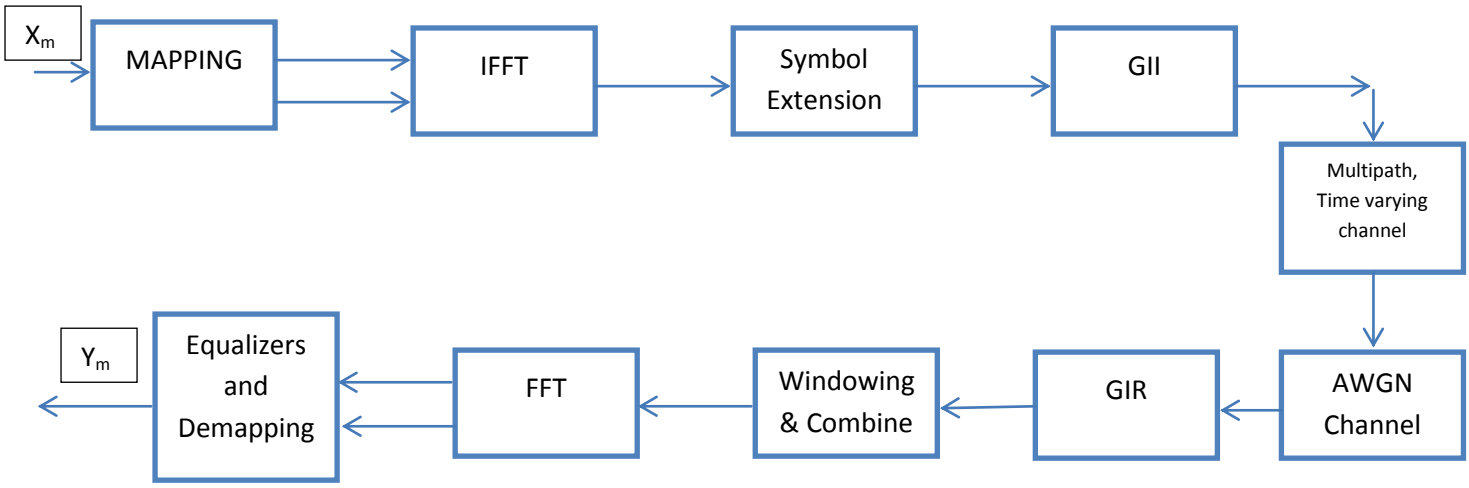

Fig 3.1 Proposed block diagram of the equivalent low-complex receiver windowing structure by the author of the base paper

In the transmitter side, guard interval appended in front of Cyclic Prefix (CP). A periodically extended OFDM symbol is inserted before the extended signal at the transmitter side.

In the receiver side, the transmitted OFDM sub data symbols are multiplied by coefficients of the window used. And the author of this paper removes the cyclic prefix from the received data signal

After that they combined information data signal part with the extended data signal part due to different nature of channel environment (that results in delay of the transmitted signal).

In this paper author uses the window technique known as frank window method.This technique is governed by the Frank in 1968.

Frank window method is used for mitigating the inter carrier interference and Bit error rate in received data signal. Hence Frank window combining technique gives the high quality performance of the OFDM System in terms of BER and ICI.

This proposed window technique was investigated for getting the estimated results. This window technique was found to have reduced the theoretical Inter Carrier Interference (ICI)

power level and Bit Error Rate (BER). The performance of the OFDM System was further validated by considering the simulation results as shown below by a graph drawn between BER and SNR.

The graph drawn below shows that BER of Frank Window Technique is the least which is shown by the blue delta line on the graph. In comparison to Chang's Window shown by purple upside down delta and Four Step Window shown by red circle line, the BER of Frank window is minimum which establishes the fact that the performance of the Frank Window Technique is best among these techniques.

The performance of the Frank window technique was compared with the four step winow and change's window techniques it was found that this proposed window method technique known as Frank Window may give the best inter carrier interference performance within the external considerations

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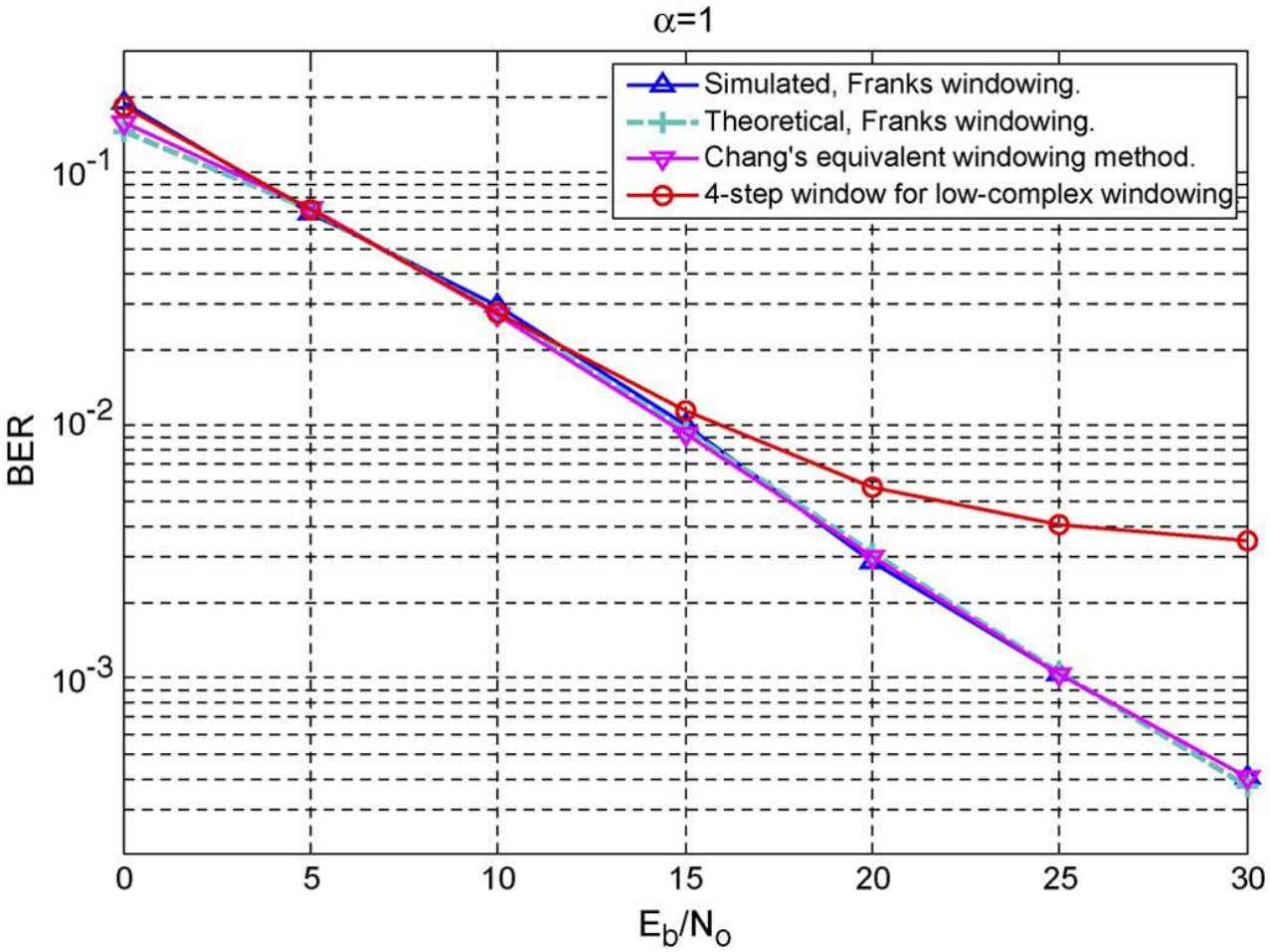

Fig 3.2 BER Vs SNR

It was concluded that Frank Window technique has reduced the Bit Error Rate (BER).

However, there may be possible scopes for further reducing the BER which will sufficiently increase efficiency in the communication.

If the ICI is removed from the received data signal then reliability in the communication between the source and destination will be increased. Keeping in concern of the above mentioned facts, a hybrid technique has been proposed by during the course of my research study.

A combination of Frank Window technique and Discrete Prolate Spheroidal Sequences (DPSS) has been used to propose a new method that would reduce BER at the great extent.

This hybrid combination would prove to be a remarkable approach in increasing the efficiency .

Both methods have been thoroughly studied to find out their positive aspects and drawbacks along with their ease of application in their relevant conditions.

The Frank Window technique finds its applications for mitigating effect of the Inter Carrier Interference (ICI) in OFDM Systems.

DPSS(having two times orthogonality) property is used for overwhelming the drawbacks of windowing technique for channel estimation. Discrete Prolate Spherpoidal Sequences (DPSS) thus provides better ICI and it also reduces chances of the BER in the received data signal. Hence, DPSS technique performance is two times better than the previous method.

Both techniques where analysed in their applicable areas. Frank window technique is useful for removing the ICI in High-Mobility OFDM applications Whereas DPSS is useful for eliminating the drawbacks of Window technique.

A new technique based on the combination of these techniques has been formulated to obtain a new hybrid technique known as DPSS-Window hybrid technique.

This hybrid technique provides low Bit Error Rate (BER) and also reduces the Inter Carrier Interference (ICI).

These results have been verified using MATLAB.

The simulation results obtained provides verification of a better performance of communication between the Transmitter and Receiver. The verified simulated results using MATLAB has been discussed in the next chapter.

3.2Objectives

The proposed research objectives are given as

1. To Know various techniques to reduce BER in MIMO-OFDM

2. To propose techniques to increase the channel estimation in MIMO-OFDM such as DPSS, Frank Window Techniques, etc.

3. The proposed technique will be based on filtering technique based on OFDM .

4. To implement proposed techniques and compare the results with the existing technique in terms of BER.

3.3 Research Methodology

In this work, the DPSS (Discrete Prolate Spherpoidal Sequences) channel estimation technique will be applied with the forward propagation to decrease the bit error rate in MIMO-OFDM.

The technique of DPSS has the double orthogonal property over the finite and infinite channel values. This property reduces the bit error rate in MIMO-OFDM where the windowing techniques had been used for channel estimation. The DPSS is used at the receiver side with back propagation technique, as the back propagation technique will help to run DPSS technique in the iterative manner, at each iteration, error gets reduced.

The basic step of a research work to define the research problem in a clear way and represent it in the form of some research questions around which complete research will be performed. In this proposed following research questions are defined

a) Will the proposed system will reduce the ICI ?
b) Will the system reduce the Bit Error rate and Interference Ratio ?
c) Is the proposed system better than the existing system ?

3.3.1 Sources of Data

The proposed system is about the enhancement reliability in MIMO OFDM in case of Interference.

The basic knowledge representation respective to work is given below:

a) The implementation of the MIMO OFDM in the system respective to the scenario definitions that include number of nodes.

b) Maintaining the Statistical information regarding each node as well as each communication over the network.

c) Representation of different parameters using which the decisions will be taken place.

3.4 Research Design

Initial models were based on the Kalman Filter along with the concept of repetitive slots and Correlated Channel Mapping.

These models have been thoroughly studied and many modifications have been found to be applicable on it.

In the proposed work to improve the Kalman Filter along with the concept of repetitive slots and Correlated Channel Mapping, further research ideas for modifications has been proposed in this research.

The proposed model of the system is shown below with the help of a block diagram.

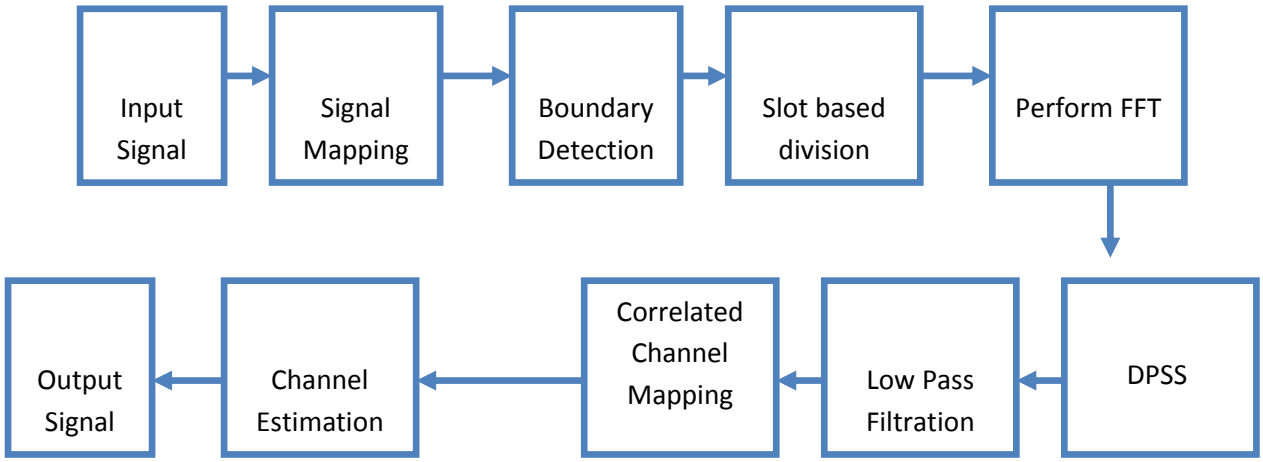

Fig 3.3 Block Diagram of Proposed Model

The initial steps of the proposed system are same as of traditional MIMO OFDM network. Here proposed work implemented just after performing the FFT blocks.

After that the channel mapping and estimation will be performed. If the channel is not mapped properly some filteration is performed so that the mapping will be done accurately. After that signal modulation etc. is performed.

As we get a mapped modulated signal, divide the signal in repetitive slots with some boundary definition.

It is expected that the proposed system will improve the network with reduction of error rate and the interference ratio. The basic terms related to the system includes:

3.4.1 ICI

The main drawback of the OFDM System is the effect of inter carrier interference which reduce the performance of the OFDM system . Inter carrier interference is occurred due to the carrier frequency offsets between the source and destination.

Carrier frequency offsets is occurred because of the Doppler frequency is added in the transmitted data signal in the communication channel environment.

Carrier offset problem may be occurred due to different frequencies between the source and the destination frequency of oscillators .

Hence this frequency offsets problem breaking the orthogonality between the small sub data signal and small sub carrier which results the inter carrier interference problem in the transmitted data signal. Hence ICI is a serious drawback of an OFDM System.

In the earlier years the authors give the many method for fighting with the inter carrier interference problem.

The method or techniques of removing the ICI in the received data signal at the receiver side are equalization used in frequency domain, windowing technique and also ICI may be removed by the self inter carrier cancellation technique.

The researcher proposed the improved technique that is known as improved kalman filter which is used to reducing the effect of the inter carrier interference by estimating the recived data signal.

3.4.2 PAPR

The performance of the OFDM System is decreased due to the higher PAPR. PAPR is the main disadvantage Of the OFDM System. The major existing problem at the transmitter side where the Gain is saturated in the radio frequency amplifier.

PAPR may be reduced by using the transmitted signal at the transmitter side in which the power of data signal is lower than the saturated amplifier power.

In this PAPR is analyzed by using Kalman Filter based Statistical analysis and based on obtained value the Phase variation is performed to control the PAPR.

3.4.3FFT/IFFT (Fast Fourier and Inverse Fast Fourier Transformation)

FFT is used to perform Frequency domain transformation. And IFFT is used to convert OFDM sub-channels into time domain. OFDM sub-channels are converted into time domain using IFFT due to generated distinct small signal of IFFT modulates each of the sub-channels into a precise orthogonal carrier.

3.4.4 Carrier Frequency Offset

OFDM requires high degree of synchronisation to maintain sub-channel orthogonality. So, performance level depends on the accuracy in estimating Carrier Frequency Offset. Basically, CFO is the difference in carrier frequency at transmitter side and the receiver side.

In wireless communication using OFDM due to mobility of the users, more accurate frequency offset control is needed to ensure that subcarriers are orthogonal. CFO estimation is needed because of the difference in frequencies of transmitter and receiver, which if not estimated can cause large bit errors in the received signals.

3.4.5 Kalman Filtering

In radio communication systems, filtering is a desirable factor.

In the radio communication system the information data signal is spoilt by the noise present in the commination channel environment. Hence a filtering technique is used to discard the noise from the EM environment signals when we extracting the important data information.

Kalman filter technique is used to filter the noise in the received data information signal at the receiver side. Hence this filter technique gives the better performance of ICI and BER.

This filtering technique is having the mathematical equations that help us to reduce the mean square error from the received data information signal.

Hence Kalman filtering technique is worked efficiently and recursively reduce the effect of the noise in the transmitted data information signal in the communication channel environment.

This filtering technique is useful where the unknown parameter is added to the data information signal and this unknown parameter is efficiently estimated by the kalman filtering technique used at the receiver side.

Hence the kalman filtering technique provides the optimum performances analysis at the receiver side.

Kalman filtering technique is worked well when all the noise is Gaussian noise and it can be easly minimized the squared error in the transmitted data information signal at the receiver side.

Hence Kalman filter is an optimal based method for giving the optimum performance of the OFDM System.

Kalman filtering technique is an easy technique compared with the real time method and this filtering technique can easily develop the algo for reducing the effect of the noise in the communication channel environment.

The kalman filtering technique can be modelled under the unknow disturbances added in the transmitted data information signal

The Kalman filter maintains the estimates of the state:

$$\hat{\mathbf{x}}(k|k) \quad - \text{estimate of } \mathbf{x}(k) \text{ given measurements } z(k),\ z(k-1),\ldots$$

$$\hat{\mathbf{x}}(k+1|k) \quad - \text{estimate of } \mathbf{x}(k+1) \text{ given measurements } z(k),\ z(k-1),\ldots$$

and the error covariance matrix of the state estimate

$$\mathbf{P}(k|k) \quad - \text{covariance of } \mathbf{x}(k) \text{ given } z(k),\ z(k-1),\ldots$$

$$\mathbf{P}(k+1|k) \quad - \text{estimate of } \mathbf{x}(k+1) \text{ given } z(k),\ z(k-1),\ldots$$

Kalman filtering technique may be designed into several steps and this filtering technique is having its significance for estimating the transmitted data information signal in the communication channel environment which is having unwanted unknown parameter has to be estimated using this filtering technique.

:

0. Known are $\hat{\mathbf{x}}(k|k), \mathbf{u}(k), \mathbf{P}(k|k)$ and the new measurement z(k+1).

1. State Prediction $\hat{\mathbf{x}}(k+1|k) = \mathbf{F}(k)\hat{\mathbf{x}}(k|k) + \mathbf{G}(k)\mathbf{u}(k)$

2. Measurement Prediction: $\hat{\mathbf{z}}(k+1|k) = \mathbf{H}(k)\hat{\mathbf{x}}(k+1|k)$

Time update

3. Measurement Residual: $\mathbf{v}(k+1) = \mathbf{z}(k+1) - \hat{\mathbf{z}}(k+1|k)$

measurement update

4. Updated State Estimate: $\hat{\mathbf{x}}(k+1|k+1) = \hat{\mathbf{x}}(k+1|k) + \mathbf{W}(k+1)\mathbf{v}(k+1)$

where **W**(k+1) is called the Kalman Gain defined next in the state covariance estimation.

Where w(K) is the Gaussian vector matrix .

.

3.5 Discrete Prolate Spherpoidal Sequences channel estimation (DPSS)

DPSS technique is an channel estimation based technique which is used to give optimum BER performance of the OFDM System .

DPSS is also know an DPSS filtering technique which is having two time of orthogonal capability over the finite sequences and the infinite series set simultaneously.

This filtering based technique is worked well where we use the window technique scheme and this filtering based DPSS technique has the potential to remove the disadvantages of the window technique.

When this DPSS filtering technique is combined with window technique scheme and gives best Bit error performance of the OFDM System over the communication channel environments.

This hybrid technique is known as DPSS- window Technique which is use for reducing the effect of inter carrier interference analysis.

And this hybrid filtering based technique also give the optimum BER results.

DPSS filtering technique provides the higher accuracy for estimating the communication channel environment.

The performance of the OFDM System may be increased in terms of ICI and BER by using the Modulated DPSS filtering method which is having 2 time capability than the DPSS filtering technique.

Modulated DPSS technique is known MDPSS filtering based technique which is having the capability to provide more accuracy in extracting the data information signal in the noisy communication channel environment.

In addition to the channel estimation techniques, Adaptive modulation can be Implemented with LS and DPSS both channel estimation techniques for 2x2 MIMO-
OFDM systems.

3.6 Adaptive Modulation Technique

Adaptive modulation Scheme has a capability to provide the optimum BER and spectral efficiency in the noisy communication channel environment.

This modulation scheme is worked well in the slow fading environment and gives the better BER performance of an OFDM System.

In the radio communication Systems higher Signal to noise ratio help us to reduce the bit error by using the slow fading environment .

The Adaptive modulation scheme find that which of coding and protocols are used in the wireless channel environment [11]

We can easily increase the data rate level for GSM based System with the help of the channel coding and modulation scheme in the wireless communication channel environment.

These two hybrid scheme is used to give the optimum BER performance and also capable to provide robust transmission of the data information signal.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 An Overview of Matlab Environment

MATLAB is a high-level language and interactive environment that enables to perform computationally intensive tasks faster than traditional programming languages such as C, C++, and Fortran.

1. Introduction and Key Features
2. Developing Algorithms and Applications
3. Analyzing and Accessing Data
4. Visualizing Data
5. Performing Numeric Computation
6. Publishing Results and Deploying Applications

MATLAB is a high-level technical computing language and interactive environment for algorithm development, data visualization, data analysis, numeric computation. Using the MATLAB product, can solve technical computing problems faster than with traditional programming languages, such as C, C++, and Fortran. We can use MATLAB in a wide range of applications, including signal and image processing, communications, control design, test and measurement, and analysis, and computational biology. Add-on toolboxes (collections of special-purpose MATLAB functions, available separately) extend the MATLAB environment to solve particular classes of problems in these application areas. MATLAB provides a number of features for documenting and sharing work. MATLAB code can integrate with other languages and applications, and distribute MATLAB algorithms and applications.

4.2 Solution Implementation

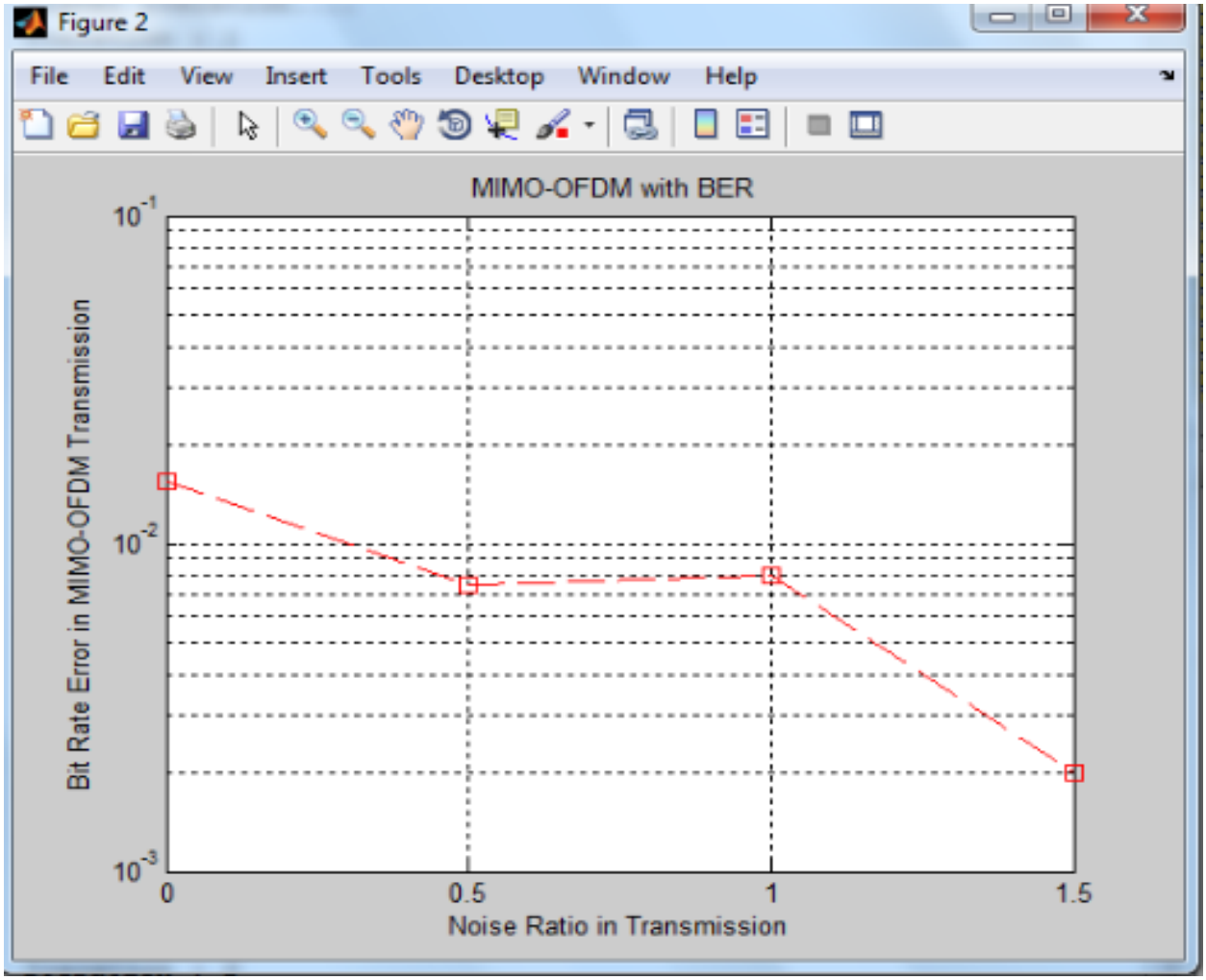

Fig 4.1Bit error rate due to noise in OFDM using Frank window technique

As illustrate in fig. 4.2.1 red line shows the noise ratio in MIMO-OFDM transmission

The above MATLAB simulation graph shows the variation between BER and SNR by using the Frank Window technique.

It shows that there can be further scopes for BER reduction .

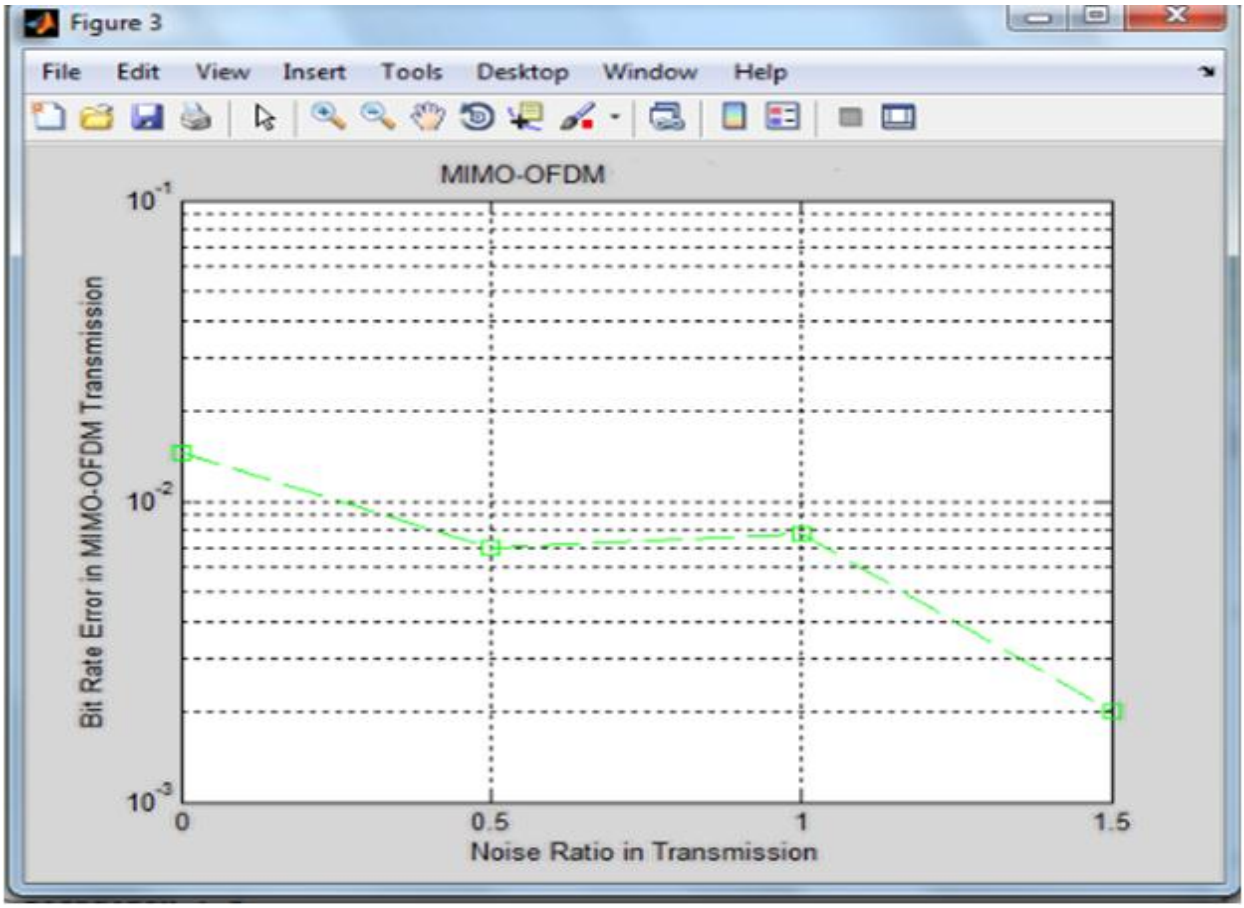

Fig 4.2 BER graph for MIMO OFDM using DPSS-window technique

As illustrate in fig. 4.2.2 green line shows noise ration using DPSS filter Technique in MIMO-OFDM transmission.

The above graph shows the variation of BER Vs SNR using my DPSS-Window hybrid technique.

The simulated MATLAB Graph shows that there is reduction in BER which is lesser than the Frank window Technique.

The reduction in BER shows that this hybrid technique provides better performance.

Hence the existing techniques can be replaced by the DPSS-Window hybrid technique.

4.3 Comparison of both Techniques

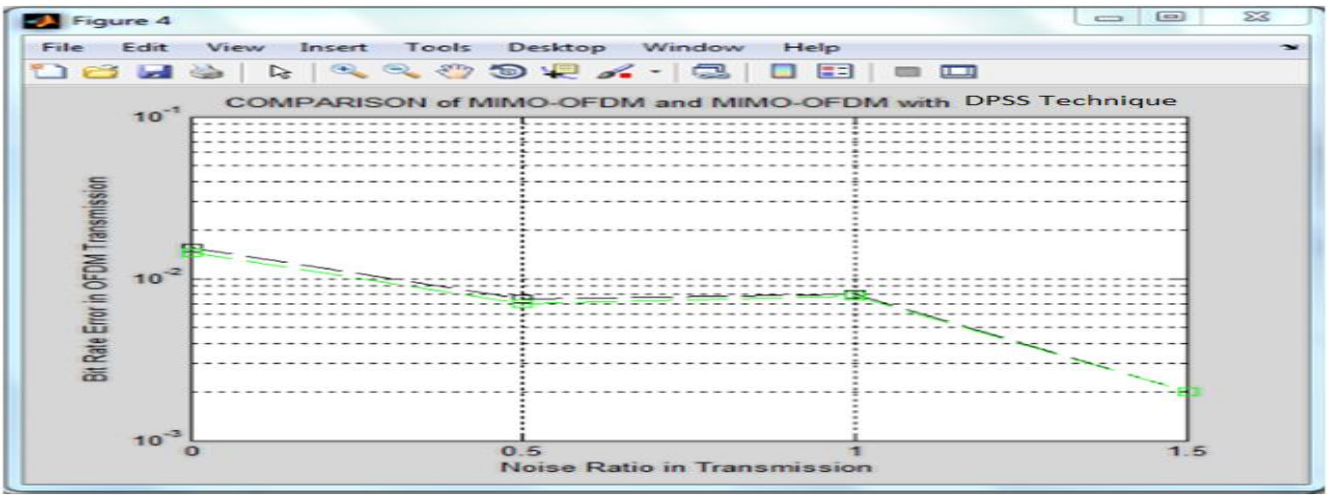

Fig.4.3 Comparison of both techniques

As illustrate fig.4.3.1 black line shows noise ratio in MIMO-OFDM using Frank window technique and green line shows noise ratio in MIMO-OFDM with DPSS Filter. It shows that noise ratio and bit error rate is less with DPSS as compare to MIMO-OFDM using Frank window technique.

4.4 Conclusion

In this proposed technique we conclude that the OFDMs MIMO is the efficient technology for data transfer at higher bit rate.

Due to the nature of MIMO, higher bit error rate had reduced the efficiency of the network. Therefore, reducing the bit error rate was the essential need to optimise the performance of the communication between the transmitter and the receiver.

A new idea has been proposed based on the combination of window techniques and DPSS filtering technique.

DPSS technique when combined with the Frank window technique provides better BER performance. Thus this hybrid technique provides better BER outcomes than the existing proposed techniques.

This new technique is the mathematical technique in which we DPSS is used for reducing the bit rate error. Hence; this new proposed technique provides better performance.

The simulation results show that proposed technique is more efficient than the previous techniques.

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