IMPROVEMEMT IN BER USING CHANNEL CODING AND TRANSFORMATION TECHNIQUES IN WIMAX SYSTEMS

DISSERTATION-II

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By

Manmohit Singh (11604674)

Under the Guidance of

Komal Arora

Assistant Professor, L.P.U

School of Electronics and Electrical Engineering

Lovely Professional University

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TOPIC APPROVAL PERFORMA

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Supervisor Name : Komal Arora **UID :** 15703 **Designation :** Assistant Professor

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SR.NO.	NAME OF STUDENT	REGISTRATION NO	BATCH	SECTION	CONTACT NUMBER
1	Manmohit Singh	11604674	2016	E1622	8054257731

SPECIALIZATION AREA : Wireless Communication **Supervisor Signature:** ________________

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3	Project Academic Inputs: Project topic is relevant and makes extensive use of academic inputs in UG program and serves as a culminating effort for core study area of the degree program.	6.33
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PAC Member 3 Name: Jaspinder Singh	UID: 19601	Recommended (Y/N): NA
DAA Nominee Name: Amanjot Singh	UID: 15848	Recommended (Y/N): Yes

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PAC CHAIRPERSON Name: 11106::Dr. Gaurav Sethi **Approval Date:** 14 Nov 2017

CERTIFICATE

This is to certify that Manmohit Singh bearing Registration no. 11604674 have completed objective formulation/Base Paper implementation of the thesis titled, **“Improvement in BER using channel coding and transformation techniques in WIMAX systems ”** 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 thesis has ever been submitted for any other degree at any university.

Komal Arora
Assistant Professor
School of Electronics and Communication
Lovely Professional University
Phagwara, Punjab

Date:

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Manmohit Singh

Reg.No: 11604674

DECLARATION

I, Manmohit Singh, student of M. Tech under Department of Electronics and Communication of Lovely Professional University, Punjab, hereby declare that all the information furnished in this Dissertation-I report is based on my own intensive research and is genuine.

This report does not, to the best of our 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.

Manmohit Singh

Reg.No. 11604674

ABSTRACT

WIMAX was introduced by the Institute of Electrical And Electronics Engineers, which designated two different standards for fixed and mobile services. The growing demand of the This research work mainly focuses on the OFDM implementation in the WIMAX systems for the data transmission at physical layer. The focus of work is attracted towards the encoding and transformation techniques in the OFDM system. The LDPC encoding is implemented to make the system feasible even in high deep fading environment. The transmitted data is sent using BPSK modulation techniques. The performance of the system in Rayleigh, Rician and AWGN channel is studied. The use of different channel encoding techniques, pre-coding techniques, and transformation techniques are introduced and analyzed on MATLAB simulation. The forward error detection and correction capability of LDPC codes is presented over the system with pre-coding by the Walsh Hadamard transform. The BER performance is analyzed for the LDPC encoding technique with the pre-coding.

LIST OF ABBREVIATIONS

WiMAX	Worldwide Interoperability for Microwave Access
FCC	Federal Communications Commission
OfCOM	Office of communications (UK)
ITU-R	International telecommunication Union
ETSI	European Telecommunications Standards Institute
DSL	Digital Subscriber line
WiFi	Wireless Fidelity
FFT	Fast Fourier Transform
IFFT	Inverse Fast Fourier Transform
DWT	Discrete Wavelet Transform
WHT	Walsh Hadamard Transform
OFDM	Orthogonal Frequency Division Multiplexing
CP	Cyclic Prefix

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CHAPTER 1
INTRODUCTION

1.1 WIRELESS SYSTEMS

The communication in last few decades had attracted the research interest of the scientists and the organizations due to its features at reasonable cost. The wireless communication is the way of transfer of information or data in between two or more different devices without any application of any electrical transistor being an intermediate physical object for the transfer [1]. It was initially used in 1890 for the first radio transceiver technology, but gained maximum of the attention in 1980s and 1990s, then further in 2000s. The telecommunication companies and organizations focused on the wireless technology by introducing new technologies starting from voice communication to the current generation demand of the big data over the wireless access in all urban and remote geographical regions around the globe, with different eye-catching applications and gadgets [2]. The wireless communication uses the frequency spectrum which is regulated by national organizations such as FCC, OfCOM, ITU-R and ETSI. The frequency spectrum is allocated to the different organizations and standards defined in accordance with the application of use. The wireless communication has different applications such as mobile telephones, data communications, energy transfer, medical technologies and peripheries [3]. The demand of broadband data connections were previously based on the wired networks, but now a days it has reached to the wireless networks with flexibility in mobility and data rate. The wireless systems are mainly has the transmission loss due to fading, ISI and due to Doppler frequency shift [4]. The wireless systems are more prone to fading which is encountered by various countermeasures to improve the system profile. The scenario for current wireless systems can be well explained by figure 1.1.

The wireless systems had been evolved as the basic network systems providing different attractive features by fulfilling the basic need of the today’s world. The system mainly focuses on the mobility and the data rate achieved by the advancement in the technologies for the provision of QOS for the user. The evolution made the basis as the data rate and mobility provision in the different technologies.

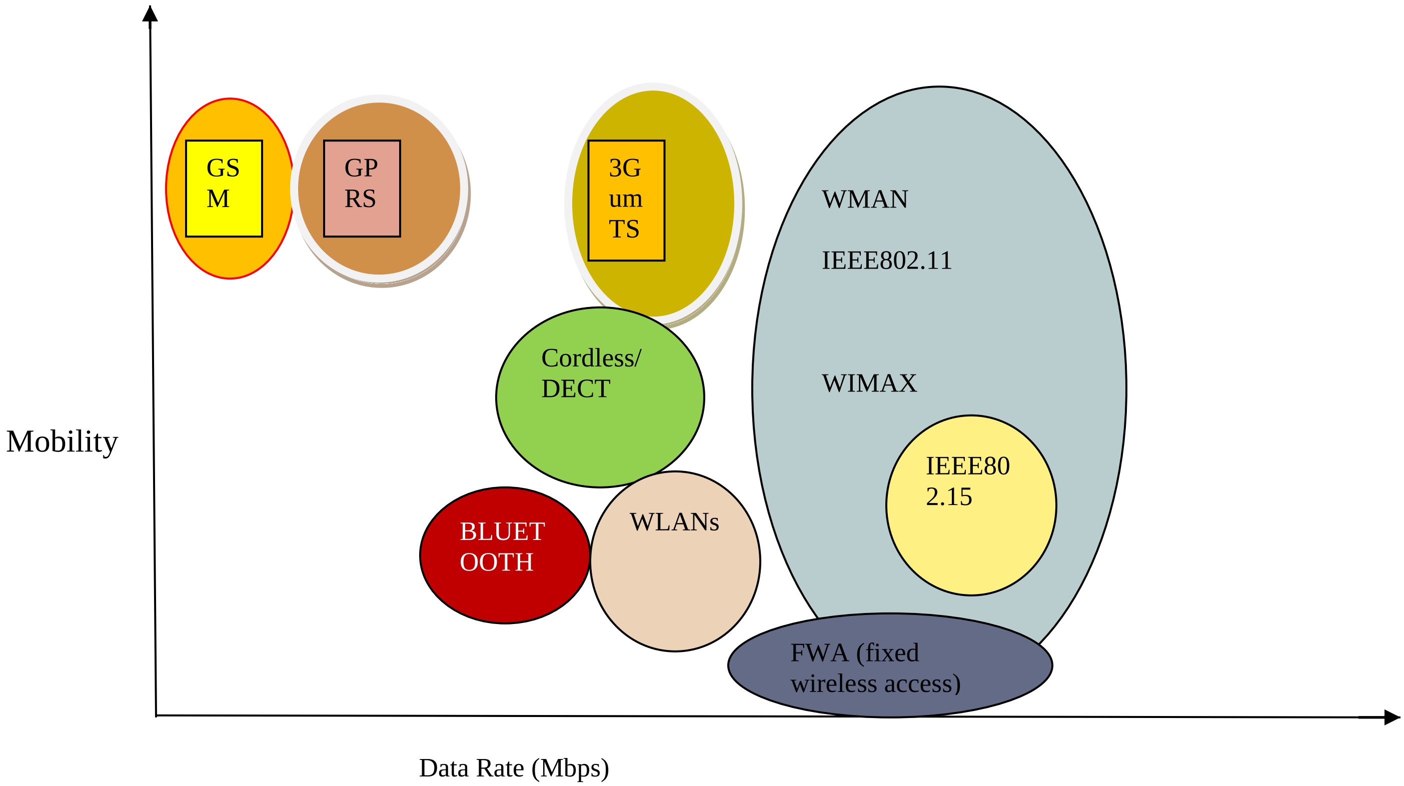

Figure1.1- Wireless Systems

1.2 EVOLUTION OF WIMAX SYSTEMS

The growing demand of broadband services, being the primary and basic need of today's digital world, different telecommunication organizations came across different solutions starting from the wired to wireless networks [5]. The internet has developed from being the basic and academic tool for millions of users around the globe, which caused a huge development of broadband technologies. There are different wired broadband technologies being in the market such as DSL. The technology switched to wireless due to mainly the high installation and maintenance cost, especially in remote and rural areas [6].

Considering the same as main objective along with the demand of higher data rates for a plenty much of new applications such as VOIP, video streaming, interactive gaming and multimedia conferencing, WIMAX has evolved as the solution provider for some advanced features combating with the existing WIFI technology of high mobility, large geographical coverage area and high data rates [7]. There is a family of two separate technologies: fixed and mobile WIMAX.

There are different standards proposed accordingly the features and applications of use are featured gradually with the last decade from the evolution of technology up till this time. The WIMAX evolution, generation and different standards are only described and regulated by the WIMAX FORUM, which is composed by more than 522 members comprising the majority of operators, component and equipment companies in the communications sector including some known big names such as Intel, AT&T, Nokia, Samsung, Motorola and Apple etc [8].

The frequency spectrum allocation with different bandwidths is allocated to different geographical regions as shown in the table below:

REGION	**TYPICAL FREQUENCY BANDS FOR WIMAX**
EUROPE	2.5, 3.5 and 5.8 GHZ
USA	2.5, 3.5 and 5.8 GHZ
CENTRAL AND SOUTH AMERICA	2.5, 3.5 and 5.8 GHZ
SOUTH-EAST ASIA	2.3, 2.5, 3.3, 3.5 and 5.8 GHZ
MIDDLE EAST AND AFRICA	3.5 and 5.8 GHZ

Table 1.1: FREQUENCY BANDS FOR WIMAX (based on Geographical regions)

The different WiMAX certification profiles for fixed and mobile WiMAX are given in table 2 and table 3 [9], which declares the frequency band, channel bandwidth and type of duplexing used in the technology.

FREQUENCY BAND	CHANNEL BANDWIDTH(MHZ)	DUPLEXING
3.5 GHZ	3.5	TDD
	3.5	FDD
	7	TDD
	7	FDM
5.8 GHZ	10	TDD

Table 1.2: Fixed WiMAX

FREQUENCY BAND	CHANNEL BANDWIDTH(MHZ)	DUPLEXING
2.3-2.4 GHZ	5	TDD
	8.75	TDD
	10	TDD
2.305-2.320 GHz 2.345-2.360 GHz	3.5	TDD
	5	TDD
	10	TDD
2.496-2.69 GHz	5	TDD
	10	TDD
3.3-3.4 GHz	5	TDD
	7	TDD
	10	TDD
3.4-3.8 GHz 3.4-3.6 GHz 3.6-3.8 GHz	5	TDD
	7	TDD
	10	TDD

Table 1.3: Mobile WiMAX

The different standards and profiles for WiMAX represent difference in application of the system. The different standards for the WiMAX are given below with specifications.

1.3 OFDM

Considering the need of increasing computing and communication environment for high data rate connections to support the integrated services of voice, video and data, several technologies came into existence to support the consumer's demand of services to maximize the bandwidth availability with maximum QOS. Orthogonal Frequency Division Multiplexing (OFDM) is the most promising technique to support this need over wireless channels. The basic principal approached by Orthogonal Frequency Division Multiplexing introduced by chang [10] in 1966, made the technique more popular in robustness for fading channel environments. The use of portable data access devices, is mostly equipped with OFDM as their background of operation providing a solution for bandwidth utilization and maximum availability by using multiple carrier transmission mode and gained the popularity due to its advantageous features. Basically advantages of OFDM are the multipath delay spread tolerance [11], immunity to frequency selective fading channels [12], efficient modulation and demodulation [13], high transmission bitrates [14], high spectral efficiency [15] and lower multipath distortion [16]. The orthogonality principle of the system makes the reduction in data loss with accuracy and high data rate achievement by multiplying the data symbols with common mathematical sine and cosine functions. Due to the orthogonality the corresponding data symbols are spaced at a phase difference of 90 degrees, which means that the integral of the product of two signals is zero over a time period as shown in figure 1 [17]. Multi-carriers used in OFDM makes the system more susceptible of frequency selective fading in the wireless channel with a promise of reduction in probability of signal loss through the channel [18]. In single carrier modulation there could be probability of the single carrier signal to get attenuated or lost due to the irregularity in the wireless channel which is improved by the use of multiple carrier signals carrying the huge information by dividing into different subparts [19].

The conventional OFDM system uses IFFT at its transmitter side for the frequency domain to time domain localization and reversal of time to frequency domain for the RF signal is done at the receiver side by the implementation of FFT algorithm [20], which is shown in figure 2. A cyclic prefix is added to increase the delay spread in the signal to remove and reduce the inter symbol interference before the data transmission occur, and along with providing the robustness to the system [21]. Somehow, the addition of cyclic prefix to the data signal reduces the efficiency of the system by consuming the bandwidth [22][23], which is shown in figure 3. The length of cyclic prefix in OFDM system depends mainly on the length of multipath channel.

Prior, OFDM systems were equipped with simple block encoding algorithms while later on it had came up with advanced encoding algorithms viz. convolutional codes [24], reed-solomon codes [25], turbo codes [26] and various other codes [27][28].

Basic OFDM System Block Diagram OFDM is sensitive to nonlinear distortions [29] because of several carrier signals leading to significant envelop variation as high peal-to-average-power ratio (PAPR) [30], which is shown in figure 4. For the reduction in PAPR various techniques had been proposed like amplitude clipping, clipping and filtering, coding, partial transmit sequence (PTS), selected mapping (SLM), interleaving, tone reservation, peak windowing, and envelop scaling.

The researchers mainly focus on the reduction of bit-error rate and PAPR of the system for the robustness and efficiency. For that purpose a huge research work had been done and still in progress on the encoding and time-frequency localization processes in the system framework scenario to make it efficient. The basic areas of improvement in OFDM system are requirement of linear power amplifiers [31], reducing the PAPR [32], reduction in guard interval or cyclic prefix [33], reduction of modulation complexity, inter-symbol-interference [34], and inter-carrier-interference [35]. These improvement areas are correlated with each other in a pebble stack scenario, the arrangement of each pebble depends on other, if one is detached from the position, stack would be fallen down or would be changed. Similarly, to make the OFDM system efficient in specific feature depends on other features, not a single block enhancement could improve the whole OFDM system, there would be a compromise with some features.

The OFDM is providing the data rates much higher than other technologies on the basis of multi-carrier transmission which has been there in the technology as the basis. The technical advancements and amends are still in progress to grow a system with more efficiency. The OFDM block diagram is represented in the figure 2.

When the bandwidth B is divided in to the N number of subcarriers having the sub band is equal to B/N is known as the Multicarrier signal with the length $-\left(\frac{N}{2}-1\right)\ to\ \frac{N}{2}$. Each of this narrow band signal is immune to Fading and in comparison to single single-carrier system data rates are improved and significantly there is increment in the total band width. Multi carrier transmission scheme is for i^{th} subcarrier is defined as:

$$Fi = \frac{i * B}{N} \quad (1)$$

Fi is known as the center frequency of the i^{th} sub carrier, and it is valid for length $-\left(\frac{N}{2}-1\right) \leq i \leq \frac{N}{2}$.

Let Xi is the transmitted data on i^{th} subcarrier then, modulated data stream will be

$$Si(t) = Xi * e^{2*Fi*\pi*t} \quad (2)$$

Similarly for N sub carrier there will be N data stream, hence the Multicarrier transmission will be

$$S(t) = \sum_i Si(t) \quad (3)$$

Where, $S(t)$ = Multicarrier composite transmitted signal, $Si(t)$ = i^{th} data stream modulated on to the i^{th} subcarrier.

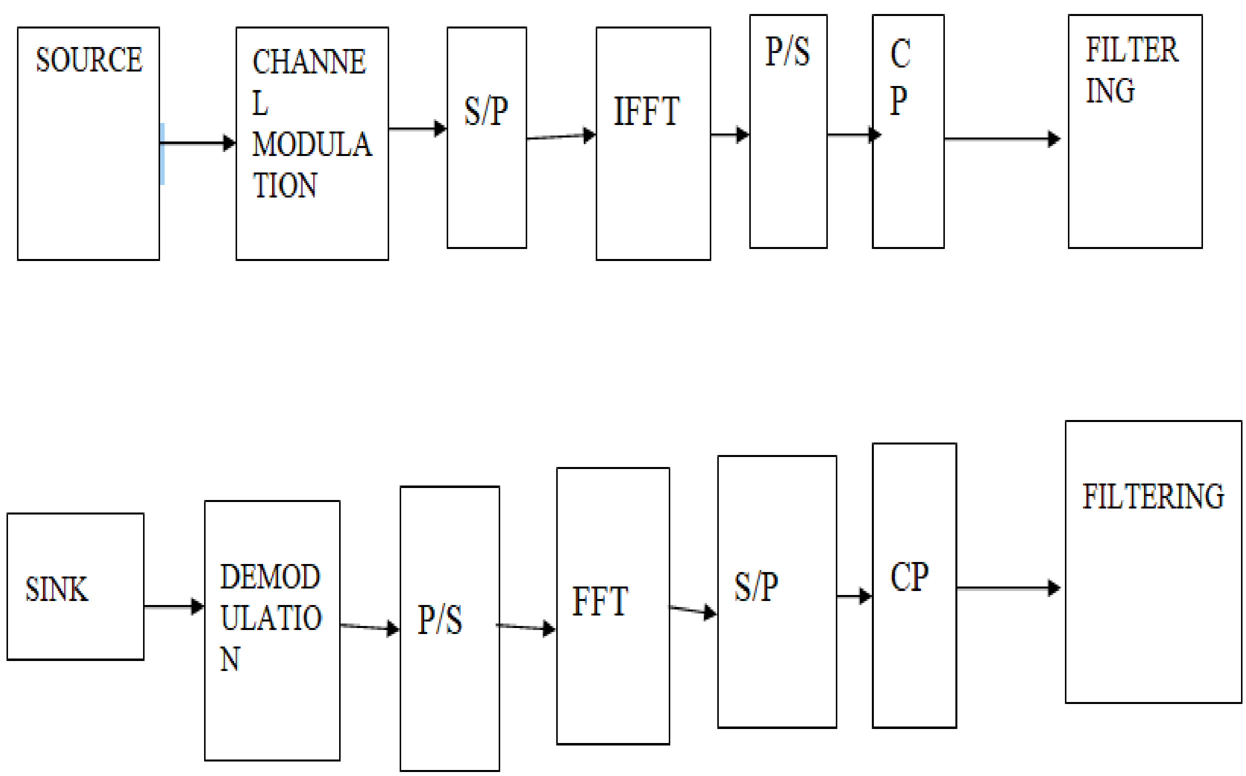

Figure 1.2: OFDM block Diagram

Schematic diagram for multicarrier transmitter and receiver is shown in figure 2.

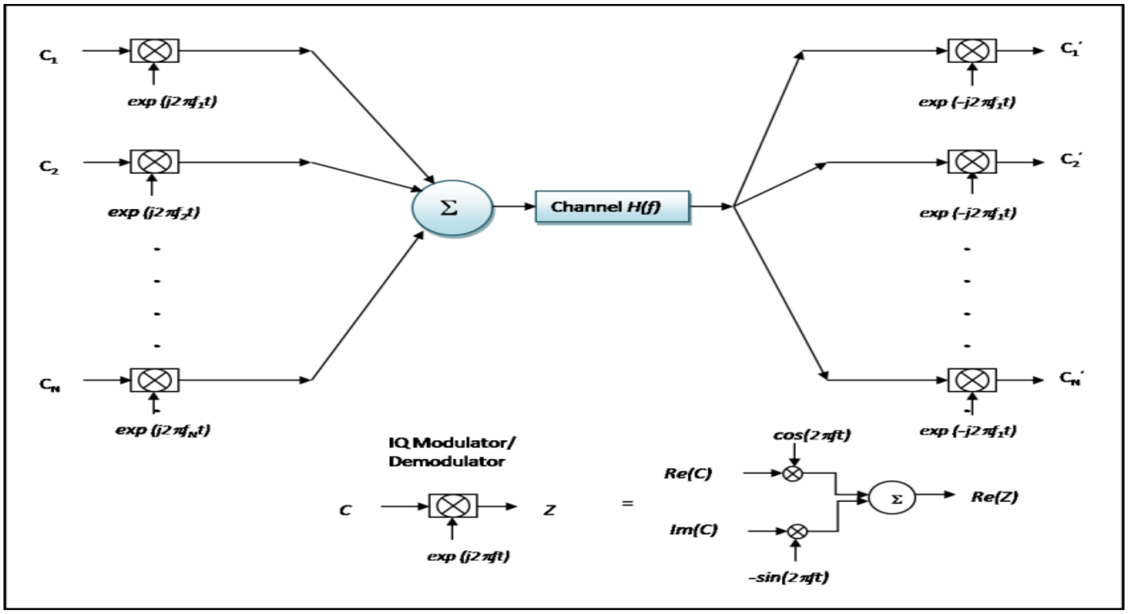

Figure 1.3- Schematic Diagram for Multicarrier Transceiver

Now, at the receiver side if noise is ignored in channel then signal will be

$$y(t) = S(t) = \sum_i X(i) e^{j*2\pi*Fi*t} \quad (2.4)$$

Further coherently demodulated each sub stream with corresponding subcarrier will be

$$Cr = \frac{B}{N}\int_0^{N/B} y(t)(e^{j*2\pi*Fl*t})^* dt \quad (2.5)$$

After putting the value of $y(t)$ it will be

$$Cr = \frac{B}{N}\int_0^{N/B} \sum_i X(i) e^{j*2\pi*Fi*t}\,(e^{j2\pi Flt})^* dt$$

$$Cr = \frac{B}{N}\int_0^{N/B} \sum_i X(i) e^{j2\pi B/N(i-l)t}\,dt \quad (2.6)$$

Now condition is $\int_0^{N/B} e^{j*2\pi*\frac{(i-l)B}{N}*t} dt = \begin{cases} 0, & i \neq l \\ \frac{N}{B}, & i = l \end{cases}$

Hence due to this condition all subcarrier except i^{th} subcarrier will be orthogonal to each other. Equation will further simplified as

$$Cr = \frac{B}{N}\int_0^{N/B} (Xl + \sum_{i\neq l} X(i) e^{j*2\pi*B/N(i-l)*t}) dt$$

$$Cr = \frac{B}{N} * Xl * \frac{N}{B} + 0$$

$$Cr = Xl \quad (2.8)$$

Hence Xl is the recovered signal from Coherent Demodulation.

Where,

Cr shows the equation for correlation

$\frac{B}{N}$ is equal to signaling factor

* in equation (2.6) shows the conjugate

Fl is for l^{th} subcarrier

Xl is equal to $e^{j2\pi lB/Nt}$

Length of l is equal to $-\left(\frac{N}{2}-1\right)$ $to\ N/2$

Since $\frac{B}{N} \leq Bc$ where Bc is coherent bandwidth, each subcarrier experiences frequency flat fading. Hence, there is no ISI in time domain.

The OFDM block diagram is basically consists of various blocks to be implemented for the achievement of the parallel transmission of data by the different sub-carriers. The data from the backhaul is fed into the encoder and interleaver for the achievement of forward error detection and correction in the transmission. The data which is now ready with a level of encryption i.e. controversial to say because the data is not encrypted as such but the plain data is now modeled into some other form by the encoder and interleaver, is given to the modulator for different constellations such as different PSK and QAM modulation techniques. The constellated data is further converted or mapped into the parallel form, which is done because it's needed for the different OFDM sub-carriers and said to be as the OFDM symbol mapping. Then IFFT is applied to the data for the time-frequency localization of the data and again converted back into serial data format before the application of the cyclic prefix. The cyclic prefix is added to each of the OFDM symbol so as to remove or reduce the effect of inter symbol interference. The CP somehow reduces the efficiency of the system by making no use of extra bandwidth, which is a point to be considered under the research for the bandwidth efficiency in the system. Then the data is converted into the analogue form before transmission. The channel impairments are the main reason for the non-idealness of the system because the system components do not make the data much corrupted as the channel affects much. The transmitted data over the wireless medium is now, received back at the receiver as the actual data along with some noise due to the channel. The reverse of the process is again carried out to detect the data and make a successful transaction. The analogue data is converted back into the digital format and the cyclic prefix which was added at the transmitter side is now removed and then the back to parallel form of data is made in accordance to make the each OFDM symbol as different blocks of data source. The different OFDM symbols are now localized back by the application of FFT block and converted into the serial form. The data is now de-modulated back by the same constellation as used by the transmitter side and decoding and interleaving is carried back to recover the actual form of plain data. The data received back at the receiver is similar to the data at transmitter side with a probability of corruption. The data corruption in between the transmitter and receiver is the main aspect of this research work. The improvement in the BER is focused in the system by the application of different blocks to be amended in the order and added with some more advancement.

ADVANTAGES OF OFDM

- Makes effective utilization of the range by overlapping.
- Eliminates ISI and ICI with the utilization of a cyclic prefix [36].
- It is conceivable to utilize most extreme probability decoding with as less as complexity Is less sensible to test timing counterbalances than single transporter frameworks are.
- Provides great security against co-channel interference and hasty noise.
- Channel evening out gets to be distinctly less complex than by utilizing versatile adjustment methods with single transporter frameworks.
- By partitioning the channel into narrowband sub channels, OFDM is more resistant to frequency selective fading than single bearer frameworks.
- Using sufficient channels coding and interleaving one can recover symbol lost because of the frequency selectivity of the OFDM channel.
- OFDM is computationally productive by utilizing FFT procedures to execute the balance and demodulation capacities.

LIMITATIONS OF OFDM

- It is more delicate to transporter recurrence balance and float than single bearer frameworks are because of spillage of the DFT.
- Nonlinear enhancement wrecks the orthogonally of the OFDM signal and it is exceptionally sensitive to ISI and ICI.
- The limited BER gain reducing the efficiency of the OFDM system.

1.3.1 ENCODING

Encoding in digital communication systems is meant to detect and correct the error in the transmitted data over the wireless channel with a minimum of bandwidth utilization. The source encoding is the technique to remove the redundant bits from the message signal by various methods of digital data compression and as a result, saving the extra bandwidth utilization. As, the wireless channels are more prone to distortion and randomness behavior due to its non-deterministic characteristics so it is also a basic need of the user to determine the channel budget before implementing the OFDM system. Channel encoding adds some redundant bits to the message signal for the purpose of error detection and correction through the channel [37]. Channel encoding techniques are dependent on the type of coding algorithm used and the number of bits in the sequence of the coding technique. Channel encoding is implemented in either of the way, by use of linear block codes or cyclic block codes [38]. In the linear block codes k bits input data is used to produce n bits of data depending on the set of linear combination of a set of generator code words. In linear block codes the message is divided into different blocks of k bits codeword with a combination of message and parity bits.

The cyclic prefix are added before the transmission to ensure the inter symbol interference. The transmitted signal is generated after FFT at the receiver and the PAPR is reduced by continuous iterative amplitude clipping. Use of LDPC codes with QAM modulation also helps in reduction in PAPR values to some extent, and which could also be improved by the use of quasi cyclic LDPC codes. The approximate triangular encoding is preferred due to ease of implementation and better efficiency in PAPR as compared to G-Matrix encoding [39]. Generally the complex techniques are hard to implement but an approach for ease in hardware implementation for PAPR reduction could be possible by the use of differential encoding after the modulation block and the largest time domain signal sample is used to carry out operations on the encoder [40]. BER performance could be improved by the use of iterative turbo encoding algorithm on a highly nonlinear distortion signal using solid state power amplifier. The turbo encoder is a combination of two convolution encoders with a bit interleaver, which is represented by a permutation sequence. The system is introduced with white Gaussian noise channel with PSK modulator with gray constellation ordering and demodulator with soft decoding technique rather than hard decoding because of efficiency. The system performs much better in the context of high nonlinearity [41]. The Convolutional encoded partial differential space time OFDM with interleaving helps in mitigation of ICI and making the error checking more efficient and increasing the high Doppler tolerance. The system should be equipped with a Viterbi decoder for the provision of burst errors through the channel. But the challenge arises in the performance reduction of the differential space time OFDMs as compared to coherent space time OFDM [42].

The basic encoding model is depicted in the figure 3.

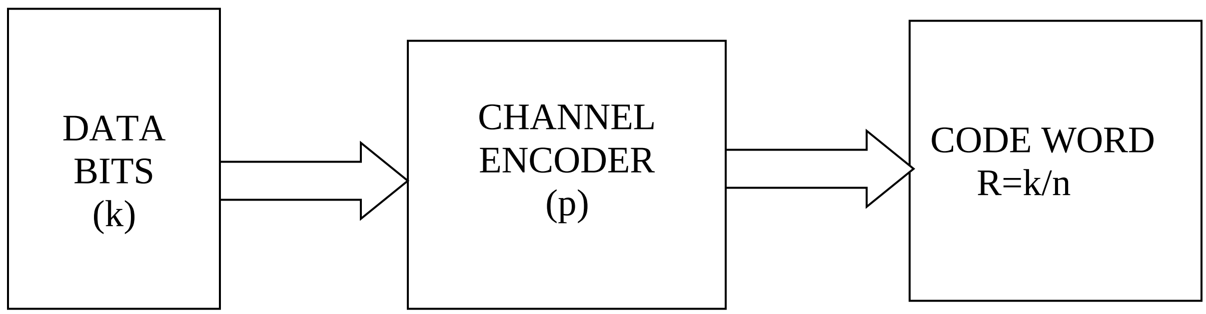

Figure 1.3- Basic Encoder Block

Linear block codes are easy for the hardware implementation and an be determined algebraically and hence could be decoded easily at the receiver side. While, an (n, k) linear code if shifted generates a new codeword is called the cyclic code. These codes are more popular due to it's algebraically properties and more efficient in error correction/detection. Some advancement arise in the efficiency of OFDM system with a use of encoding algorithms with filtering and clipping techniques to reduce the PAPR, which in turns to improve the amplifier efficiency with minimal tradeoff The important aspect of encoding the data in OFDM system depends on the synchronization techniques properties like binary or non-binary and periodic or a-periodic with low auto/cross-correlation depending on the application areas [43]. Mostly the design of sequences with specified properties for the pre-amble generation either uses, M-sequences, Gold, Kazami, Reduced complexity sequences (RC), Zadoff-chu sequences or an optimized sequence [44]. Mostly the PAPR reduction techniques have more complexity as reported in [45]. Clipping and filtering method is meant to be the simplest method because it limits and sets the peak envelop value to some pre-defined level, otherwise passes the rest. A proposal of filtering and clipping technique with Convolutional encoding and QAM modulation scheme for improvement in reduction of PAPR is described in [46]. The proposed technique firstly performs forward error correcting and detecting using Convolutional encoding and application of QAM mapping on to the input sequence, and path shift and inter carrier interference are monitored by the use of pilot carriers. After performing IFFT, the signal is clipped in time domain by amplitude clipping method. The clipping ratio and number of iteration depends on the basis of trade-off in between the

PAPR and BER calculated at the receiver end. The encoding and interleaving techniques work together to achieve the common task of forward error correction and detection. Some more advanced encoding techniques like Turbo and LDPC has an iterative nature for multiple times to recover the original data.

1.3.1(a) CONVOLUTIONAL ENCODING

The Convolutional code is a type of forward error correction and detection technique that generates parity bits and depending on the parity generated and compared to detect the error at the receiver terminal. The accomplishment of Convolutional encoding is done by the shift registers and associated arithmetic combinational operator logic that performs modulo-2 addition. The decoding of the encoded data is done easily by various algorithms like Viterbi and BCJR, which makes the coding technique a simpler technique to be implemented in the telecommunication systems. The different code rates could be easily implemented by the change on the algorithm at the encoding part by varying the number of shift registers, modulo-2 operator and the feedback back to the input at different stages. The convolution encoder provides with a block of codeword from any length of input data bits. The encoder has memory and *n* outputs at any time depend on the *k* inputs and *m* previous input blocks. The encoder is typically described by three parameters:

n= no. of bits produced at encoder output at each time

k= no. of bits to encoder at each time

m= memory of encoder

Or

K= constraint length, and given by,

$k=1+max_i m_i$

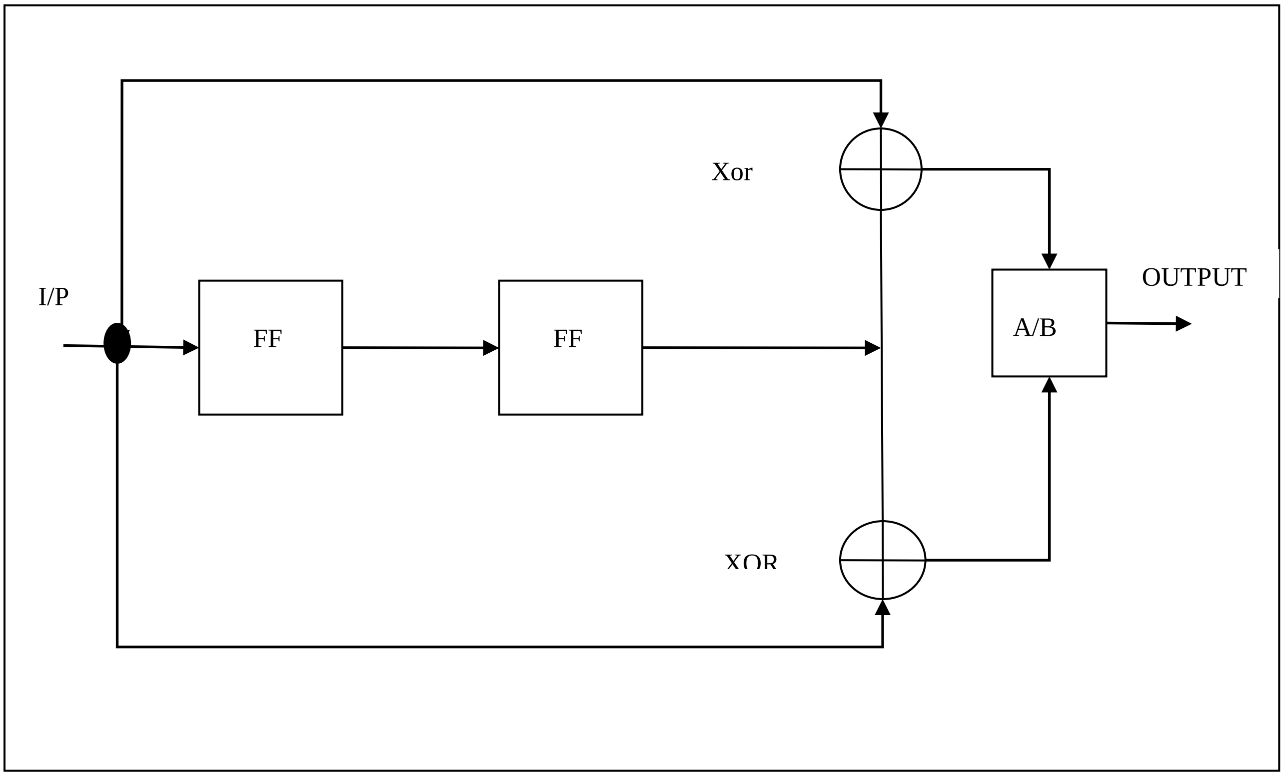

Figure 1.4-Convolutional Encoder

The recursive codes are typically systematic because the input bits are used at the output symbols and so mostly used in practice. These codes are used because of least system hardware implementation for encoding and as well the simpler decoding algorithms. These recursive gained popularity due to the use in turbo codes [47].

The basic functionality is carried out by the modulo-2 arithmetic operator, which is simply a digital logical EXOR gate output equivalent.

1.3.1(b) LDPC

The LDPC code has an ability of immunity to highly noise corrupted channel. The LDPC codes are the linear error correcting code. These are the competitors of Turbo codes in terms of performance and complexity and both are used at same physiological context. These codes are considered to be having asymptotically better performance by providing a huge trade-off in between the decoding complexity. LDPC codes were originally discovered by Gallager, as a crucial innovation of message passing being capable of achieving a significant fraction of channel capacity at low complexity. The LDPC codes have a sparse parity check matrix, which plays the significance of the coding as the most efficient encoding technique for the broadband networks. These are generally used in high data communication system networks because of comparatively high implantation cost depending on the application. The sparse matrix has always the number of 1's less than the number of 0's. The basic structure of the graph for (3-6) LDPC code generator is shown in the figure 5. The left sided round shaped nodes are variable in number while the right side nodes are fixed nodes. The construction depends on the alignement of the arrows from left to right sided nodes. The neighboring node of the graph, when arranged in the tree form makes the decoding algorithm, and that is the reason the different approaches for decoding of these codes are implemented depending on the encoding design of the encoder. The code construction is basically dependent on the Bipartite Graph [48].

These codes construction has certain rules to be followed by the constructor for the valid codeword to be generated and provides a great flexibility in construction. Each of the parity-check matrices can be partitioned into square sub-blocks of size $Z \times Z$. These sub-matrices are either cyclic-permutation of the identity matrix or null sub-matrices. The cyclic-permutation matrix Pi is obtained from the $Z \times Z$ identity matrix by cyclically shifting the columns to the right by i elements. The matrix P_0 is the $Z \times Z$ identity matrix. The basic encoding procedure is better explained with help of figure 6.

The LDPC codes are generated depending on the study of decoder behavior because these decoders have some noise threshold upto which the data can be decoded back otherwise it's hard to decode the data back when the extent is reached to the limit. When the threshold is optimized the code generation falls under two types of consideration:

- Pseudorandom approaches
- Combinatorial approaches

Construction of pseudorandom approach builds on the theoretical results for a large block size. Generally the pseudorandom codes has high decoding complexity if the block size is large otherwise the encoder is simple to implement, while, the combinational approach can be used to build the simple decoding and encoding system design [49].

The bipartite graph shows the nodes connected from which the actual decoding algorithm is implemented. The connectivity of each variable node tells the constraint size and value of each constraint block. The linearity in generated codeword of the LDPC encoder makes the encoding process little complex and infinite iterated. The coding and decoding of these codes are synchronized with each other, which implements a security add up feature in the process by the decoding of data at the receiver by only knowing the encoding algorithm used at transmitter side.

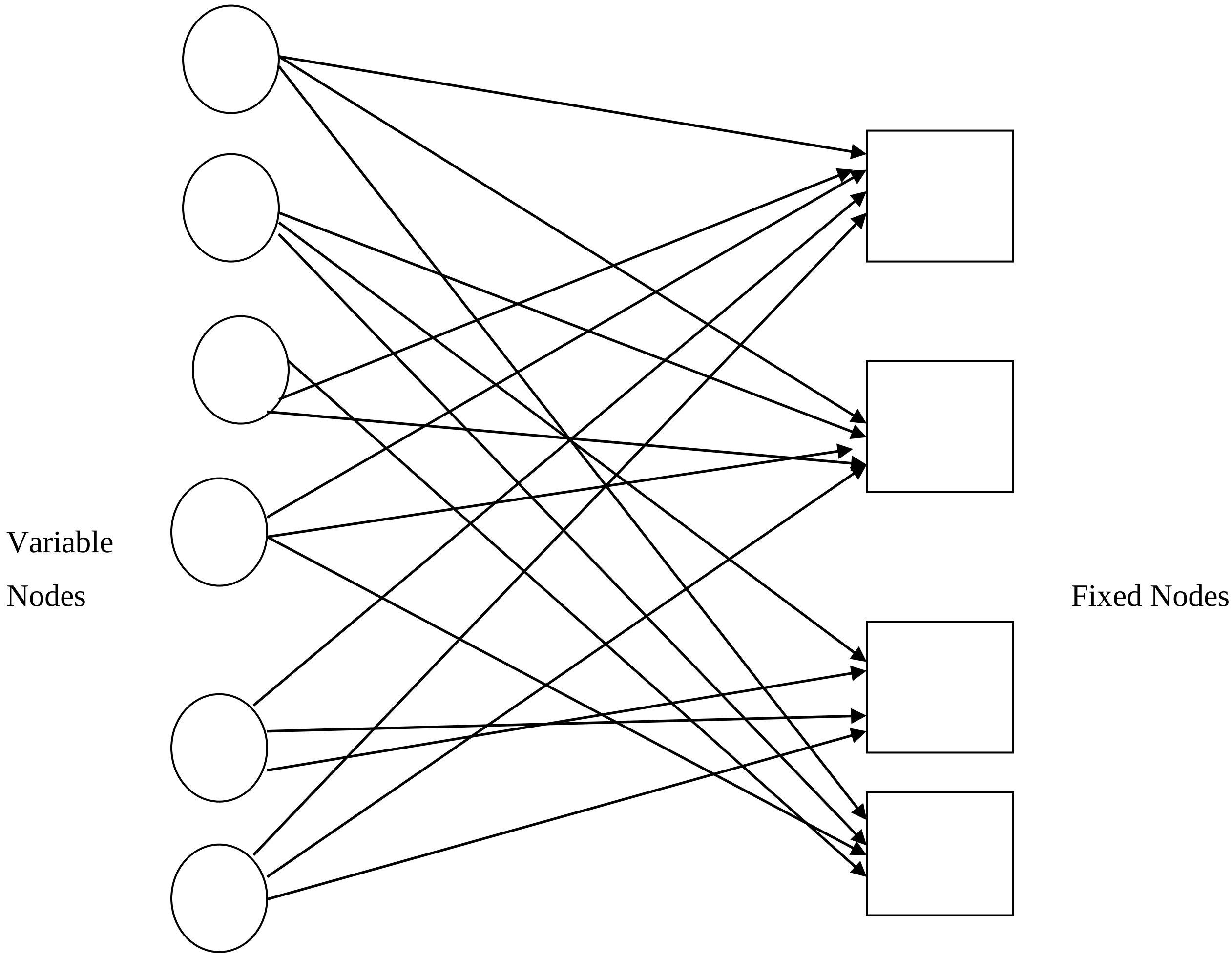

Figure 1.5- Biparatite Graph

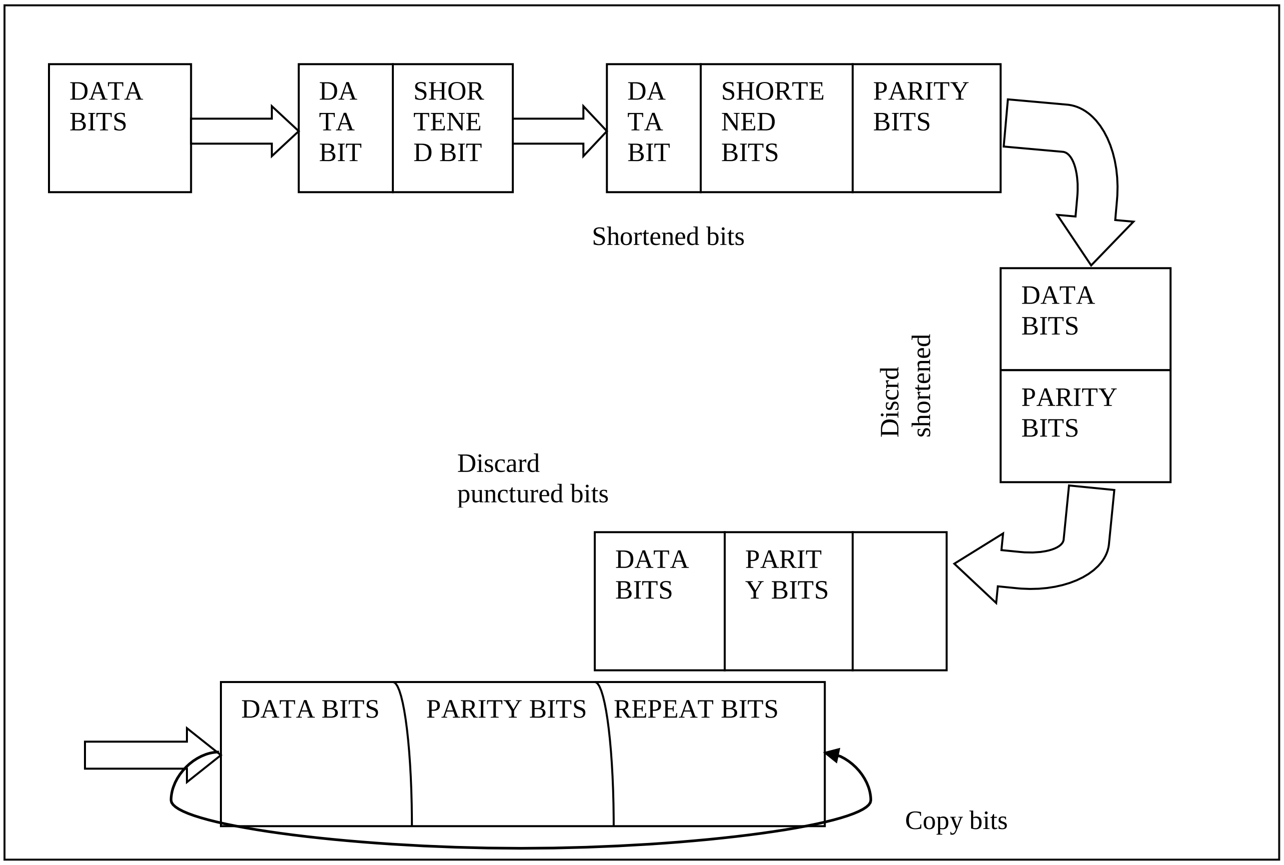

Figure 1.6- LDPC Encoder Block Diagram

The LDPC codeword should satisfy the condition of

$H.x^T = 0^T$, which expresses that it should be a null matrix of the same size when the x^T, the codeword is multiplied with the parity generated matrix H.

The BER achieved by the use of LDPC coding is less as compared to other encoding techniques, without retaining burst errors. These codes are similarly decoded by the use of maximum likelihood detection criteria as a base of the algorithms. The soft decision decoding of the LDPC codes gives the better results comparatively to the hard decision decoding.

1.3.1(c) PRECODING

Linear pre-coding is simply the linear transformation, with some transformation matrix attached with it to make the data with some redundancy before transmission so that it acts somewhat similar to the error correcting codes. The transmission through the wireless channel is meant to be easily corrupted and its random in nature, which could be resolved by availability of the channel information at the receiver side. A new trend has been introduced by the pre-coding that it is supposed that the channel information is also available at the transmitter side, which helps to improve the efficiency of the transmission over the faded channel or sometimes it may not be available at the transmitter but the redundancy introduced helps to improve the results [50]. There are various methods to implement the pre-coding in the OFDM system, but we had implemented the pre-coding through the WHT transformation. The pre-coder and decoder algorithms can be designed by the knowledge of the channel or without channel knowledge also. The transmitter power could be handled in an efficient way by the use of pre-coding with channel knowledge, which provides the better and efficient use of the transmitter power and transmission efficiency along with a significant improvement in BER.

The pre-coding can be implemented with a few simpler steps to be involved in the process. The input data sequence of some length is converted into some parallel dta sequence forming a matrix and stacked in a new column vector, which is now multiplied with the transformation matrix so that the length of the original data sequence is increased now to some length greater than the earlier, that's nothing but a fractional addition of some redundancy bits to the original data sequence. The pre-coder matrix could be a time-varying or time-invariant matrix but the transmit channel is time-invariant. It would also be the same accordingly in all cases. Once the transmit channel information is received at the receiver side, it is feed back to the transmitter and the pre-coding matrix is ontained from the transmit channel matrix. The property of OFDM to transform the frequency-selective fading into parallel flat-fading sub-channels by reducing some significant complexity at the receiver side is most attractive towards the application of OFDM system mostley in the high data applications. The pre-coding process is described in the figure 7.

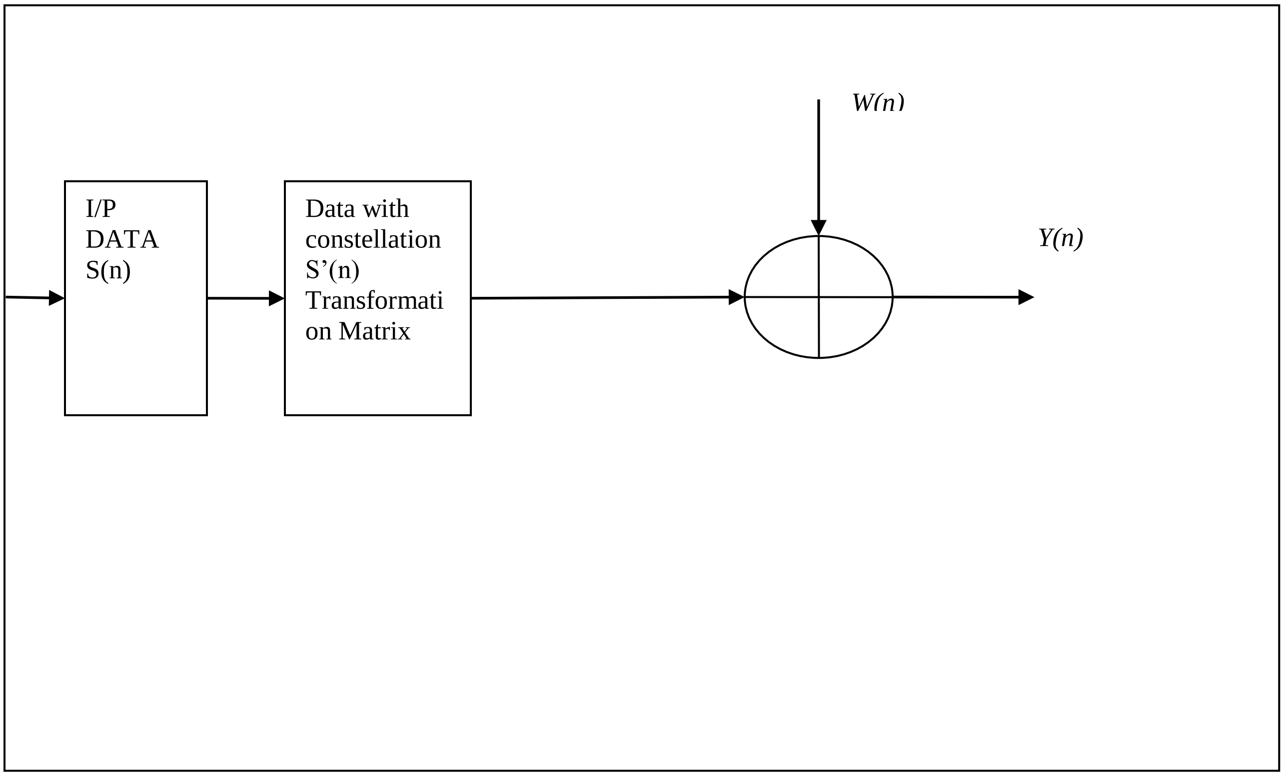

Figure 1.7- Pre-coding process diagram

Walsh Hadamard Transform is a generalized class of fourier transform, which performs an orthogonal, symmetric and linear operation on the real numbers. It decomposes the arbitrary input into some complete set of orthogonal functions for describing a discrete function, which we generally say, Walsh function in the mathematics. The Walsh Hadamard transform is generally used in signal processing, data compression, and data encryption algorithms [51]. Here we had taken the best use of the transformation by adding some fraction of redundancy to the original data with some extent of data encryption and compression.

1.3.2 TIME-FREQUENCY LOCALIZATION

Before transmission the signals are transformed from the actually generated time domain to frequency domain for the transmission of the actual RF signal. For the parallel data transmission there would be need of N number of oscillators and mixers are required to process the data in an analogue system while it is incorporated in digital system by a simple IFFT block at the transmitter side while FFT block at the receiver end. In fourier transform OFDM, the signal overlaps only in frequency domain while it overlaps in both frequency and time domain in case of wavelet OFDM.

The Fourier transform provides typically the required features with a system complexity overhead. The Fourier transform based conventional OFDM system gives the information about all frequency components but not about when, and where these frequency components occur, making a limit to use the Fourier transform as the base of OFDM system. Due to this drawback, the researchers switched to other more efficient technique to be used in place of it. While wavelet transform gives the information as a whole making the system more reliable and fast. Wavelets are the small waves with limited duration, irregularity and asymmetry, overlapping in both time and frequency domain, while the FFT-OFDM overlaps in frequency domain only. Due to the overlap in both domains, it is redundant to use the cyclic-prefix in the wavelet based OFDM system. The wavelet basis function presents different windows of different size at different frequencies representing the time-frequency resolution to the corresponding power spectrum. There are various wavelet functions such as Haar, Symlet, Coiflet, bi-orthogonal, reverse bi-orthogonal and Dubchiese, among all the Haar wavelet has better performance in context of BER performance, simplicity, memory efficiency and ease of implementation.

The wavelet provides capability which results into the several benefits in the wireless data communication networks in aspect of data creation, channel implementation, data compression, interference minimization, energy efficient networking and signal de-noising making a good candidate to replace the FFT-OFDM. The basic model of the FFT-OFDM is just replaced by the DWT and IDWT block and reducing the use of cyclic prefix from the system i.e. reducing complexity with increasing features, makes the wavelet OFDM system. The basic blocks with the working remain same as FFT-OFDM but the time-frequency localization method is changed which results into attractive features of the DWTOFDM because of the wavelet transforms properties. DWT based OFDM provides an improved BER performance in presence of Phase Noise in the signal, which is actually a Brownian process for the free running oscillator. To improve the performance in flat fading channel, normalized LMS is employed mostly. The ICI performance of OFDM system could also be improved by HAAR transform with ½ Convolutional encoding and QAM modulation in presence of AWGN noise [52]. The wavelets have the property to represent both the frequency spectrum and power spectrum of the signal, which clearly defines the betterment of OFDM system using wavelets.

1.3.2(a) FOURIER TRANSFORM

Fourier transform is the technique for the decomposition of a time function into its frequency components. Fourier transform has been in practice by long time in telecommunication networks and information theory applications due to its easiness in implementation and inverse of the fourier being present. The Fourier transform is being the primary consideration in OFDM system for Time to frequency localization and reverse of it, there it is done by the FFT and IFFT blocks incorporated in the system. The OFDM symbol mapping is done by the IFFT block. In fourier transform OFDM, the signal overlaps only in frequency domain while it overlaps in both frequency and time domain in case of wavelet OFDM. The OFDM uses the discrete fourier and inverse transform, which is given by the equation:

$$S_n(t) = \sum_{n=0}^{N-1} An\, e^{-2j\pi nK/N} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

For the inverse fourier transform it is given by

$$A_n(t) = \frac{1}{N}\sum_{n=0}^{N-1} Sn\, e^{2j\pi nK/N} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

The fourier transform is being in the consideration for the wireless networks as best candidate for the symbol mapping and signal processing with provision of auto-correlation in between the symbols.

1.3.2(b) WAVELET TRANSFORM

Wavelet transform is the transform which divides the dicreate time OFDM signal into different wavelets. These wavelets are the waves like oscillations which starts from zero, increases, decrease and then end at the same with some features of signal processing. The wavelet basis function presents different windows of different size at different frequencies representing the time-frequency resolution to the corresponding power spectrum. The wavelet provides capability which results into the several benifits in the wireless data communication networks in aspect of data creation, channel implementation, data compression, intereference minimization, energy efficient networking and signal de-noising making a good candidate to replace the FFT-OFDM. The basic model of the FFT-OFDM is just replaced by the DWT and IDWT block and reducing the use of cyclic prefix from the system i.e. reducing complexity with increasing features, makes the wavelet

OFDM system. At the transmitter side, the randomly generated data is modulated by the modulator in form of symbols, which are passed through the IDWT block before transmission. The wavelet implemented OFDM is shown in figure 8.

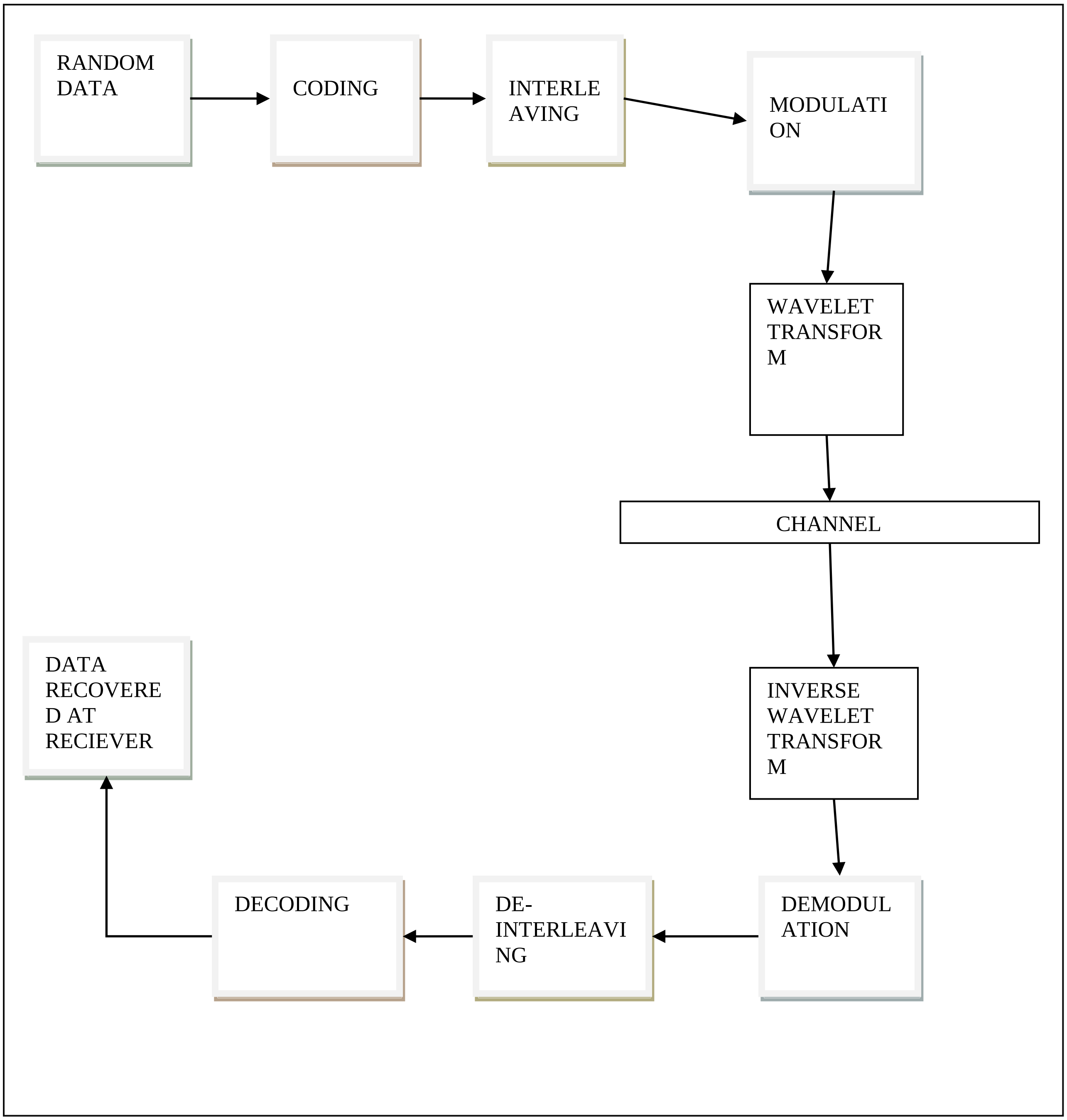

Figure 1.8- Wavelet based OFDM model

1.3.2(c) WALSH HADAMARD TRANSFORM

The Walsh Hadamard transformation is a non-sinusoidal, orthogonal linear transformation, which decomposes a signal into its basic functions namely Walsh functions. These functions are obviously +1 or -1 to retain the property of orthogonality, which reduces the occurrence of high peaks in the OFDM signals. The WHT is used because of its feature of reducing the auto-correlation in between the signals, which reduces the peak to average power problem with reduction in ISI and ICI. There is no requirement of information to be transmitted from the receiver to the transmitter. The transformation matrix kernel is multiplied here in the system to make the data added with some redundancy to corporate the aim of pre-coding. There are various methods for the same to be implemented in the system but the features shown by the WHT are most widely accepted of being orthogonal, linear, non-sinusoidal and no need of transmission of channel information back and forth. The WHT is placed in the system model in between the encoded parallel data and transformation technique as shown in figure 9.

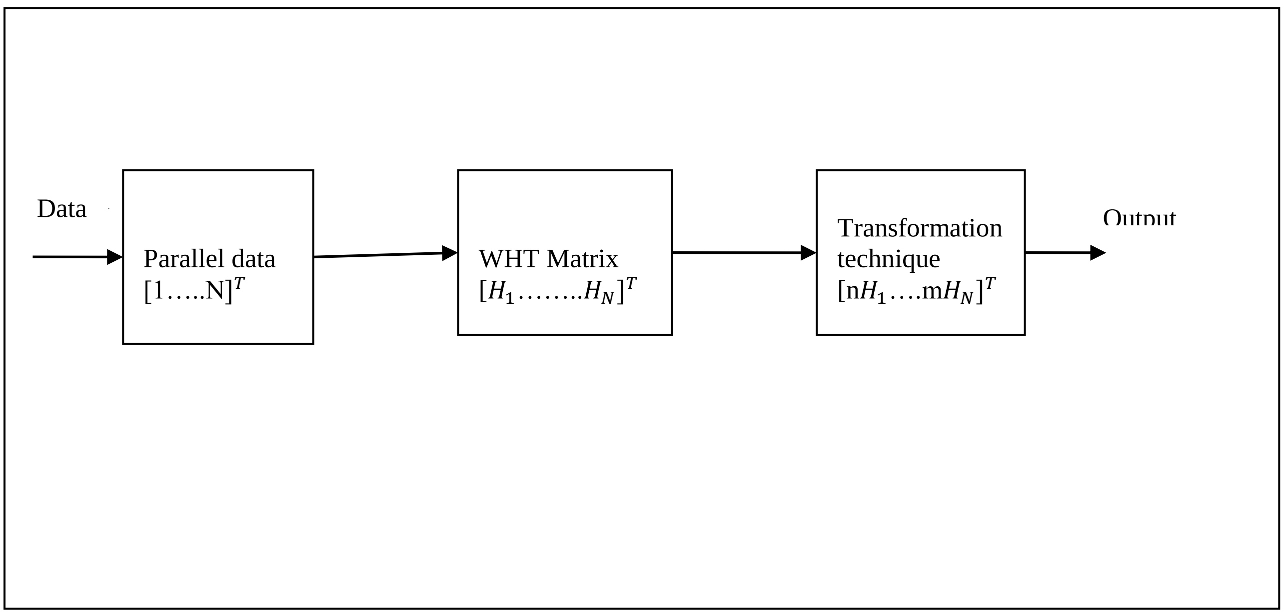

Figure 1.9- The placement of WHT block in the system

CHAPTER 2

LITERATURE REVIEW

This chapter concentrates on the literature review for WiMAX system including encoding, interleaving, use of cyclic prefix; various transmit channel responses in highly faded and ideal cases, and different transformation techniques. By studying and analyzing data through various sources, the work focused towards the improvement in BER by implementing various encoding and transform techniques.

Shendi Wang et al.[53] the paper proposes the betterment of OFDM as a candidate for the 5G uplink channel then the UFMC signals to be used. A new technique introduced i.e. polynomial cancellation coding for OFDM, which is a frequency coding technique in which the data to be transmitted is mapped onto weighted groups of sub-carriers. The technique is much less sensitive to the Doppler Effect but providing the spectral efficiency with approximately the half of it is used.

Peng Chen et al.[54] the impulsive noise in the OFDM system could be removed by the use of two algorithms namely LS based and EM based. The algorithm jointly estimates the channel impulse responses and the impulsive noise based on the least-squares principle. The second algorithm is developed with the aim to reduce the computational complexity, where the expectation-maximization method is applied to estimate the channel impulse responses and the impulsive noise iteratively. The estimated impulsive noise is then canceled from the received signal before channel equalization and channel decoding. The pilot carriers are used to estimate the signal response.

Shulun Zhao et al. [55] an adaptive polarization QAM modulation technique is used to improve the efficiency of power amplifier. The proposed work analyses the problem due to non-linearity in depolarization effect and channel estimation error in OFDM system, which could be removed with the help of polarized constellation implementation. The use of the technique results into the improvement by approximately 50 percent then earlier system model.

Hongzhong Yan et al.[56] the paper concerns about the design of distributed pre-coding in OFDM system for multiple access. The use of pre-coding in the system based on space-time coding utilizes the multipath diversity gain to alleviate the deep fade. The modeled work represents the crucial need of pre-coding technique employment in OFDM systems.

Rui Deng et al.[57] proposal for IFFT based pre-coding for the mitigation of periodic noise in OFDM system is presented with an improvement in the BER performance. The IFFT length decides the efficiency in BER value, as the increase in number of IFFT length increases the efficiency.

Kun Wang et al.[58] the introduction to an approach of LDPC codes encoded on space time and corresponding detection by the joint linear programming instead of disjunctive blocks and soft decoding algorithms by the use of QAM modulated signals and available pilot symbols. The detection algorithm reduces the complexity of decoder working even for long LDPC codes.

Li Li et al.[59] the use of LDPC in OFDM system could incorporated for the reduction in PAPR problem with the soft decision decoding for long LDPC codes using the number of OFDM symbols as the basic of decoding. The processing time is reuced with the implementation of algorithm by providing near to ideal error correcting capability and adequate PAPR reduction.

Si Shu et al. [60] the proposal of new QC-LDPC codes are introduced having efficiency for the removal of PAPR and improvement in BER for the system by introducing the inter sub-set interleaving in the codes. These codes are more practical and less complex then real QC-LDPC codes with a high range of invert ability.

Diaming Qu et al.[61] the proposal of another family of invert able LDPC codes for the reduction in high PAPR has been introduced by removing the search complexity for the new iteration of the codes. The codes in the system model perform in an improvement and achievement in least BER value. The value of BER is achieved better then the other encoding techniques by making the LDPC codes as the best candidate for the encoding purpose with reduced complexion.

Kaiyao Wang et al.[62] the research mainly focuses on the image processing with the help of LDPC codes, where the overhead of fragmentation of image is reduced or made obsolete by the use of linear coding. The coding performed the task of fermentation of image and encoding the same into different codes depending on the number of sub-carriers used in the OFDM system. The encoding presents the improvement in the efficiency in terms of BER in Rayleigh faded channel model at high SNR values.

Ezmin Abdullah et al.[63] the proposal of the work depicts the comparison of LDPC and QC-LDPC codes in AWGN channel for the improvement in BER efficiency of the system, with a reduction in encoding complexity. The paper claims for the improvement in PAPR reduction by the use of new technique for QC-LDPC codes as 13% being 9.5 % in the simple LDPC coding. The approximately triangular coding is used in the coding to achieve the same.

Paulo Montezum et al.[64] the paper proposes a significance of equalization with LDPC codes to make the system more efficient by reducing the wastage of transmitter power. The iterative block feedback equalization is used which have the same effect in error correction as the LDPC codes with the high complexity does. The system complexity, reduction in PAPR and improvement in BER is achieved at approximately equivalent complexity wih and without using the LDPC codes as the encoding technique. This paper indicates the superposition of equalization in the system rather then the highly complex LDPC codes.

Akihiko Sat0 et al.[65] the paper describes the betterment in performance of LDPC codes in highly faded environment then the convolutional encoded OFDM used in broad band systems. The code rate of the encoding makes the both encoding similar when the high code rate is used in LDPC OFDM, but it could be improved by the use of high constellations. The channel frequency response in the highly faded environments should be used for the equalization purpose in the system.

Hongming Zhang et al.[66] the proposal for the new modulation technique as index modulation in the system instead of the other conventional techniques makes the reduction in power of transmitter by making the LDPC encoded OFDM system with index modulation an implementation in vehicular networks.The technique combat with the frequency selective fading and to mitigate the impulsive noise out from the system. The betterment of LDPC coding with the index modulation is proposed from the coparision of system with different encoding techniques.

Luiz Bernardo et al. [67] introduced the study of performance of Symbolic Dynamics Chaotic OFDM signals over Rayleigh fading channels. Both Fourier OFDM and Wavelet OFDM are considered and compared with each other. The results indicated the superiority of the wavelet based system in comparison to the Fourier OFDM.

Maarwa Chefii et al.[68], the paper addresses that the power spectral density limitations of Wavelet-OFDM, analytically and experimentally that the bandwidth efficiency of Haar Wavelet-OFDM is significantly poorer than OFDM, having larger main lobe and side lobes compared with OFDM, which reduces the attractiveness of the scheme.

Sunita Sirvi et al. [69] introduced the wavelet OFDM performance over flat fading channel using NLMS equalization. Presents that bit error ratio is reduces much better due to NLMS algorithm based channel estimation than flat fading that can be modeled by Rayleigh and Rician in which later gives the improved results. Also the cyclic prefix is said to be not needed in wavelet based OFDM system. Than concludes that performance of DWT-OFDM in Rician gives better performance than Rayleigh because of including direct path signal also with reflected and scattered signals, which could be improved by using NMS algorithm. The approach introduced is based on the chaotic Baker map. The binary data is interleaved with the proposed approach prior to the modulation step. In addition to reducing the channel effects on the transmitted data, the proposed chaotic interleaving approach adds a degree of encryption to the transmitted data. The performance of the proposed approach is tested on the Discrete Wavelet Transform OFDM and the conventional Fast Fourier Transform OFDM with and without chaotic interleaving. The proposed system comprises Frequency-Domain Equalization to obtain high diversity gains over frequency selective multi-path fading channels.

Jie Yang et al. [70] image transmission based on turbo coded for variable length OFDM and error protection by using Wavelet transformation, and adaptive quantization which performs better then uniform equalization. The different models for the DWT-OFDM and FFT OFDM for both the equalization techniques, which results in reflecting the DWT-OFDM system with adaptive equalization as the best technique for improvement in BER rate.

Swades De et al. [71] the paper presents a new technique for the improvement in BER rate achieved by the OFDM system by using source-aware and channel adaptive resource allocation. The system model performs the BER rate achievement with a approximately ideal maintaining the power efficiency in consideration. The reception quality is improved at the receiver model with significant change in the given power budget.

Slavche Pejosk et al. [72] proposed work is focused in the channel estimation and pre-coding to the OFDM system with pilot added channel estimation over the Bernoulli-Gaussian sparse channel, with Lasso compressed sensing. The asymptotic increase in the capacity bound is achieved with the increase in channel estimation. A new technique is envolved in the system model with new mathematical expressions which are actually some derived functions form the previously stated standard formulae.

Manuvinakurike Narasimhasastry Suma et al. [73] a new method for reducing the PAPR and increasing BER is introduced for OFDM system by using discrete harmonic wavelet packet transformation method with tree pruning for the tree selection of the values of the least PAPR, and the results are discussed for different encoding techniques with improvement showing by the use of the Hadamard codes. The different implementation of encoding techniques is analysed in the system such as Golay codes, Hadamard codes and convolution codes.

Lu Xu et al. [74] the paper proposes a new turbo receiver design working based on the redundant information transmitted by the cyclic prefix in the OFDM system. The redundant information of the CP can be used at the receiver by using two algorithms which are namely as turbo equalization and expectation-maximization method. Both the equalization techniques are used at a time but for different iterations i.e. turbo for outer iteration while the expectation maximization for inner iteration. The employment shows a significant improvement in BER performance.

Amrit S. Bedi et al. [75] the cyclic prefix which is actually a subset of insufficient information of the actual data information received at the receiver can be used as a pre-coding technique. The pre-coder helps in the inter block suppression of the data with a large efficiency in the system in terms of BER rate achievement. The application of the pre-coder makes the bandwidth efficient system along with providing a solution for the purpose of pre-coding transformation technique.

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CHAPTER 3

RATIONALE AND SCOPE OF STUDY

Benefits of earlier Paper Published

- The modulation being the main objective for the researchers used in different applications for various constellations provide the effectiveness in the BER value of the OFDM system along with a significant reduction in PAPR value.
- The different encoding schemes makes the system highly immune to overcome the system without being into a deep fade or total breakdown of communication rather making the system strong enough to detect and correct the forward errors introduced by the channel impairments.
- The different transformation techniques implemented in the system model to replace the basic model using FFT as the transformation technique which results into improvement in the BER value of the different SNR values.
- Pre-coding in OFDM system is meant for the addition of redundancy to the original data has been the prime concern of researchers to transmit the channel information from the receiver to the transmitter to make the transmitter power effectively and efficiently used.

Scope of the Study

- The linear encoding by LDPC can be implemented for the best possible error correction and detection purpose in the highly noise corrupted channels such as in Metropolitan cities, and industrial areas.
- The WHT pre-coding serves the purpose of channel estimation signals along with provision of forward error detection and correction, which makes the system useful for the next generation telecommunication networks like in 5G.

CHAPTER 4

OBJECTIVES OF STUDY

The objectives of the proposed work are as follows:

1. To study and simulate the block and linear encoding techniques in WiMAX system and impact of various channel models on the system efficiency by implementing LDPC encoding and corresponding decoding techniques for the use in wireless broad band networks.
2. To analyze the performance of system by implementing pre-coding techniques.
3. To analyse and compare the different transformation techniques on to various channel models.
4. To implement the Walsh Hadamard Transformation based pre-coding with Wavelet transform technique.
5. To implement the WHT pre-coding on different channel models with different transformation techniques using LDPC encoding as the channel encoding and for the comparison for the efficient BER performance of the system.

CHAPTER 5

RESEARCH METHODOLOGY

5.1 SYSTEM MODEL: The adaption of two major amendments in the system model by implementing WHT at the transmitter side before modulation the data is pre-coded and processed further. Another one is by implementing the Haar transformation by replacing the FFT block for time-frequency localization purpose to be achieved. The system model which should be in accordance with the proposed model is better explained by the visual representation as shown in figure 9.

The simulation shows that the BER is improved by the method implemented by the various replacements in transformation techniques and encoding techniques with and without any pre-coding technique. The LDPC codes provide the system with a significant improvement in BER for the highly faded channel, making the best use of encoding technique. The transformation technique which we had implemented here by replacing the Fourier transformation technique is Haar, that represents the clear view of the signal in both time and frequency domain instead of frequency domain only as done by the Fourier transform. The system with all replacements and introduction of new system blocks makes a significant change in the BER value.

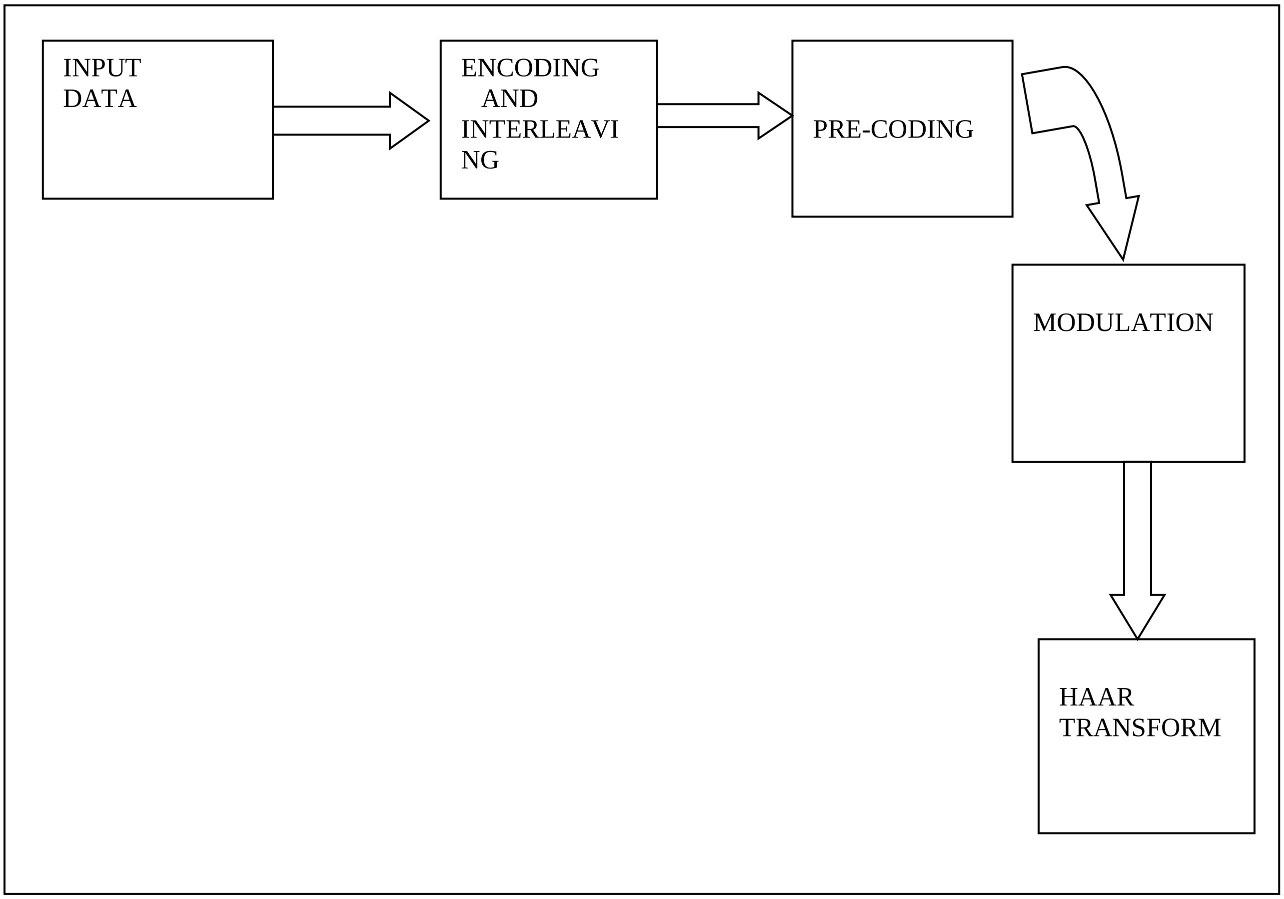
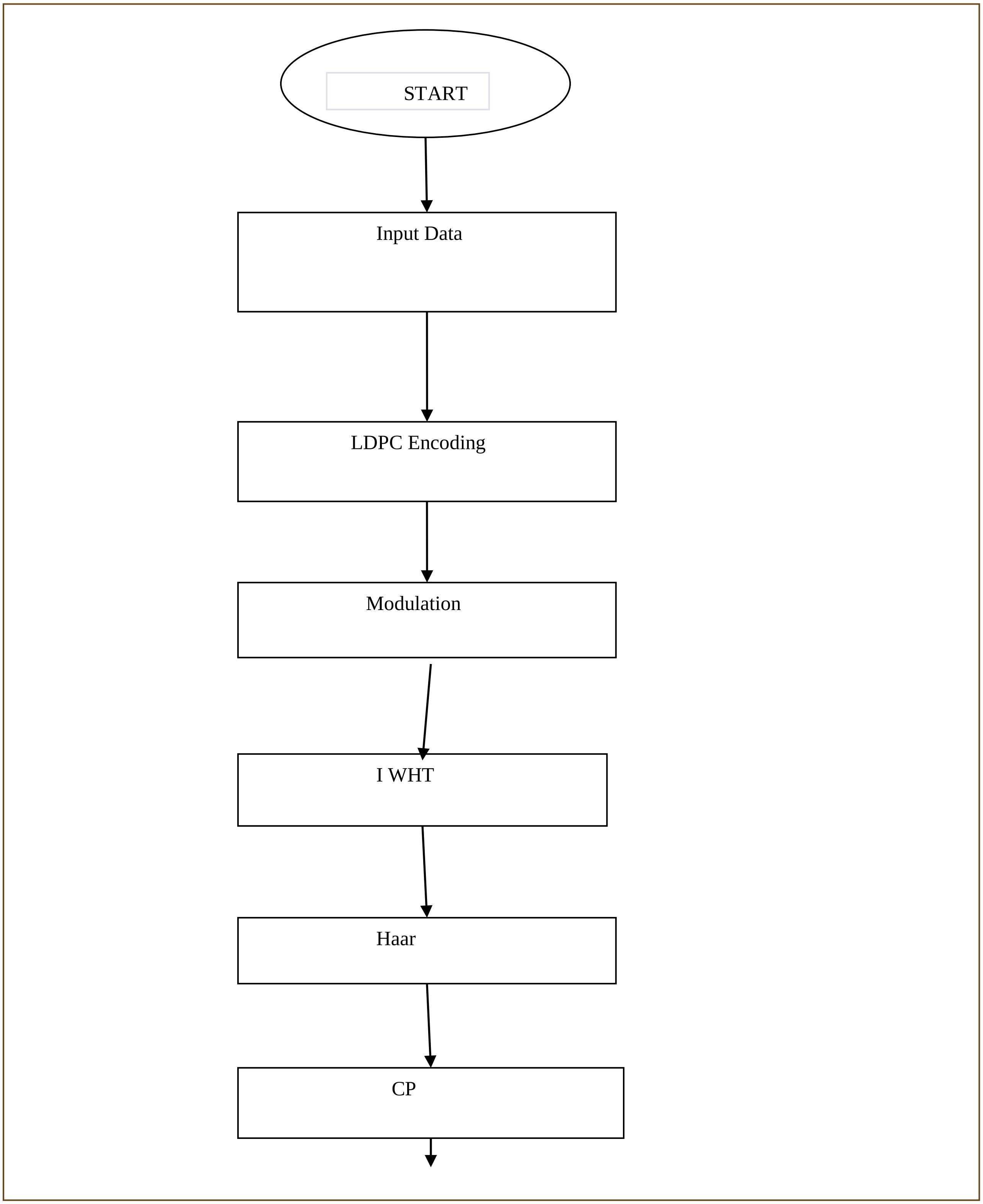


Figure 5.1- The proposed system model

5.2 PROPOSED WORK: The work proposed involves the implementation of linear encoding by LDPC codes and transformation through the Haar transformation. The Pre-coding is done by the use of Walsh Hadamard transformation matrix being as the base of pre-coding matrix multiplied with the original data, which sends the information of transmit channel from the transmitter to receiver and then back again to transmitter to make the changes accordingly in the power of signal symbols at different times so that the proper utilization of transmitter power could be done along with a significant improvement in BER rate of the system. The proposal of work is better explained with the help of the flow chart for the system blocks and processes at different levels as shown in figure 10.


START
Input Data
LDPC Encoding
Modulation
I WHT
Haar
CP

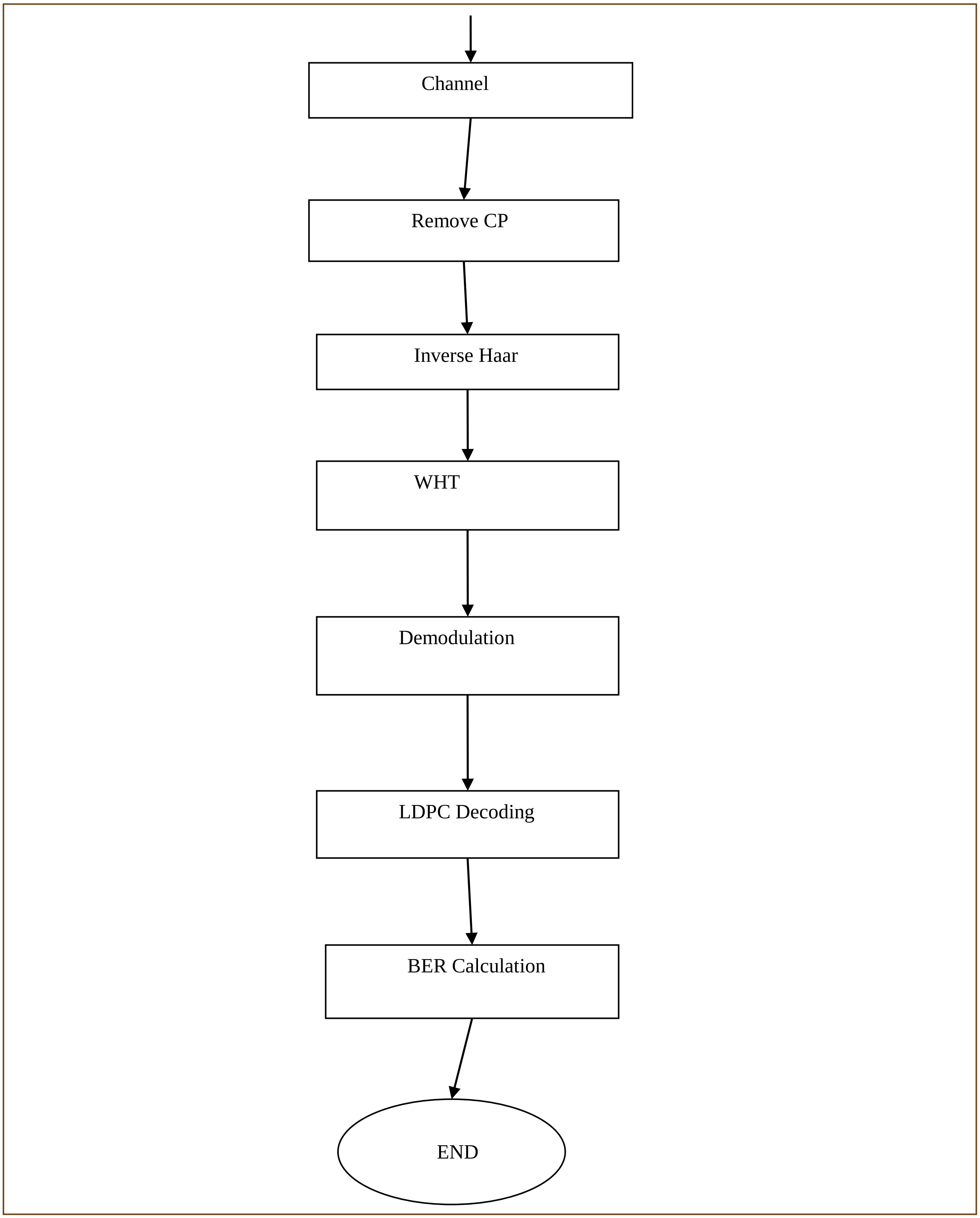


Figure 5.2- Proposed Work Flow Chart

Steps Involved in Flow Chart are described below:

1. The data encoding is performed at the first with different encoding schemes, which results into improvement in BER and ultimately reduction of PAPR, implementing the purpose of scrambling technique.
2. Encoded data is modulated as per the constellations required to achieve the data rate and depending on the number of OFDM symbols and FFT size.
3. The pre-coding using Walsh Hadamard Transformation due to its transformation matrix the data is introduced with some redundancy, which proposes the task of error detection and correction.
4. The data is transformed into parallel form and the Haar transformation introduces the benefits over the FFT transformed OFDM with an adequate amount of improvement in the mapping symbols.
5. The OFDM symbols are now introduced with some delay added at the start of each symbol with some bits copied from its end, which somehow reduces the system efficiency but helps in mitigation of ISI.
6. The data over different fading channel models is introduced with its effect over the symbols carrying information, the channel could be in deep fade or normal are considered.
7. The added redundancy in form of CP is removed first and then further moved on to the inverse Haar transformation to de-map the data back into symbols, earlier which was in serial form.
8. The demodulation according to the constellations used at the transmitter side and corresponding LDPC decoding are further done after the decoding of pre-coding used at the transmitter.

CHAPTER 6

RESULT AND DISCUSSION

6.1Results

The implementation of the system model is done for the calculation for the graph of bit error rate in the transmitted sequence of random data with the available signal to noise ratio, which is taken by the user. The implementation of proposed FFT OFDM for different channels is shown on figure 6.1.

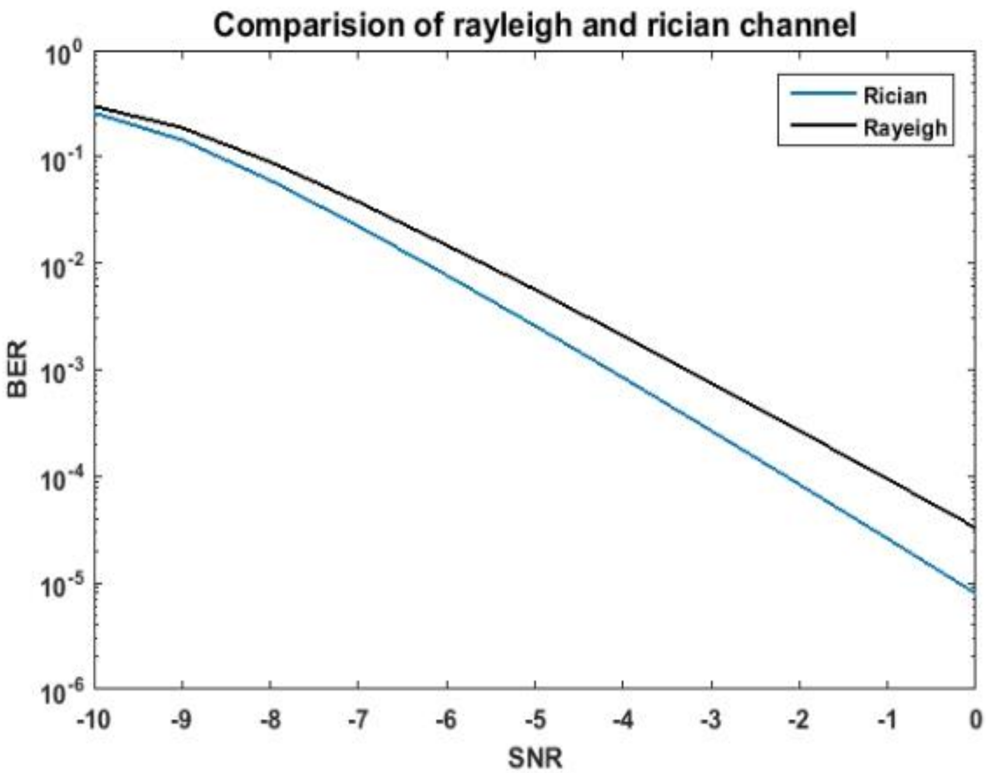


Figure 6.1- The SNR V/S BER graph for FFT OFDM system

The graph clearly reflects the efficiency of Rayeigh channel over the Rician channel. The parameters for the calculation of the results are indexed in the table 6.1.

PARAMETERS	VALUES
Random Data Length	10000
FFT size	512
CP length	n/4
Modulation	BPSK
Channel	Rician and Rayeigh

Table 6.1- Parameters for FFT OFDM

Now comes, the turn for Haar Transformation used in DWT OFDM system for the representation of BER Graph which is shown in figure 6.2.

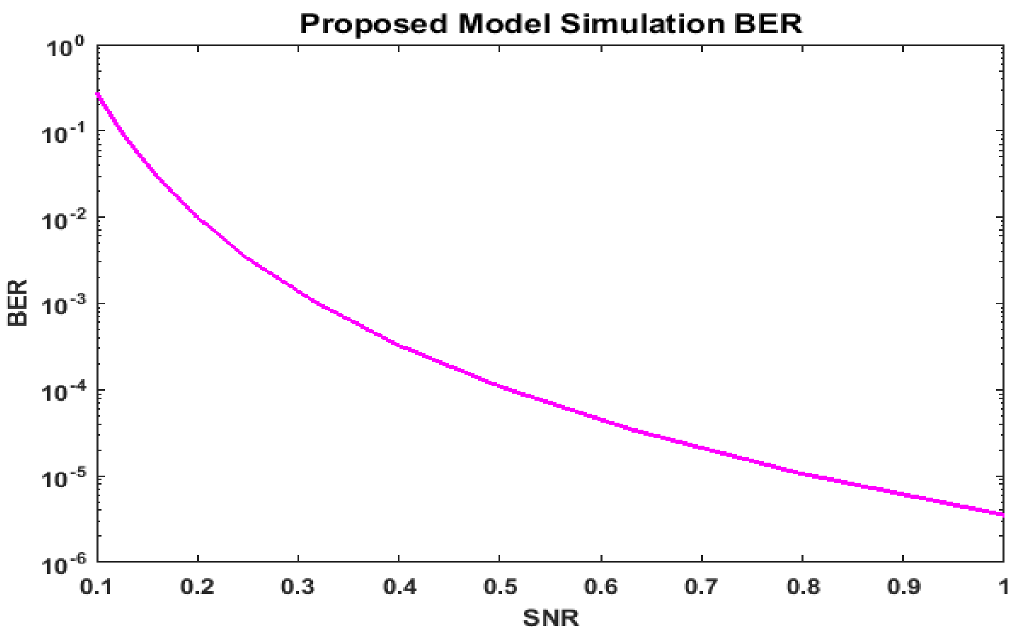


Figure 6.2- Graph for DWT OFDM system model

The results for the BER value are improved by the implementation of Haar transformation technique in the OFDM. The parameters taken in consideration for the implementation of DWT OFDM model are indexed in table 6.2.

PARAMETERS	VALUES
Random Data Length	10000
CP Length	n/4
Modulation	BPSK
Channel	Rayleigh
Encoding	Convolution

Table 6.2- Parameters for DWT OFDM

The LDPC encoded FFT OFDM system is further implemented which results into an efficiency in BER rate at low SNR values, which were earlier not achieved by the FFT OFDM and DWT OFDM system models as shown in figure 6.3 and the parameters are indexed in the table 6.3.

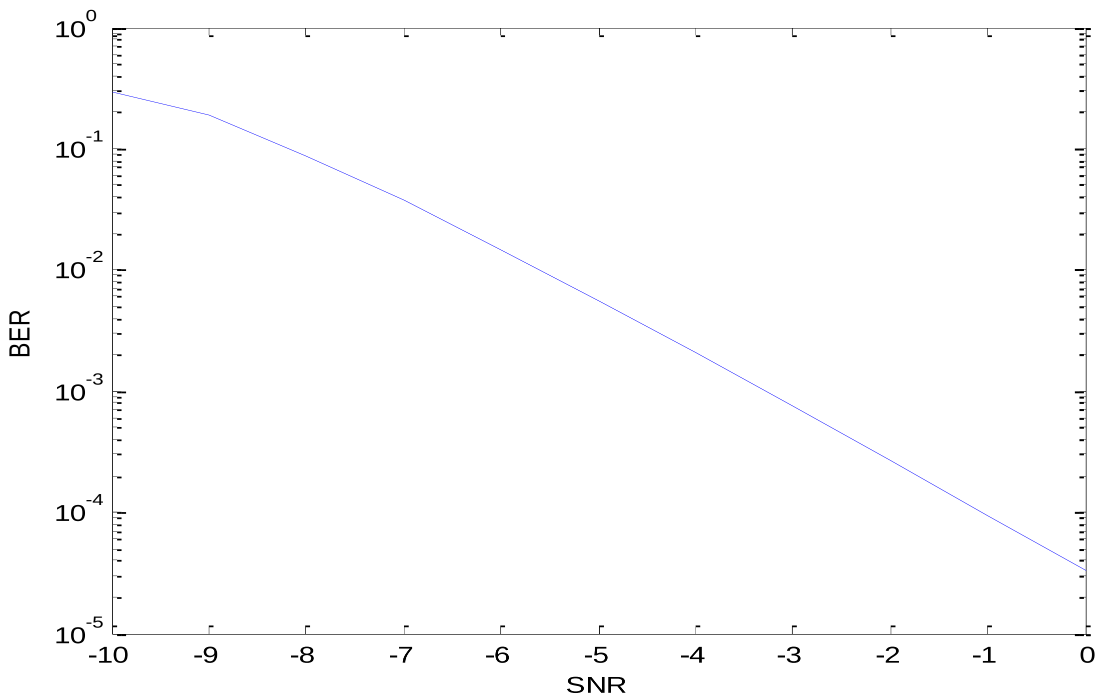


Figure 6.3- BER Plot for LDPC FFT OFDM

The LDPC codes are generated by the standardization of the parity generator matrix being the standard defined by the WiMAX Forum for IEEE 802.16. The decoding is based on the maximum likely-hood probability basis.

PARAMETERS	VALUES
Random Data Length	10000
FFT Length	512
Encoding	LDPC
CP Length	n/4
Modulation	BPSK

Table 6.3- Parameters for the LDPC FFT OFDM

The WHT pre-coded LDPC FFT OFDM system is shown in figure 6.4 with the parameters indexed in the corresponding table 6.4.

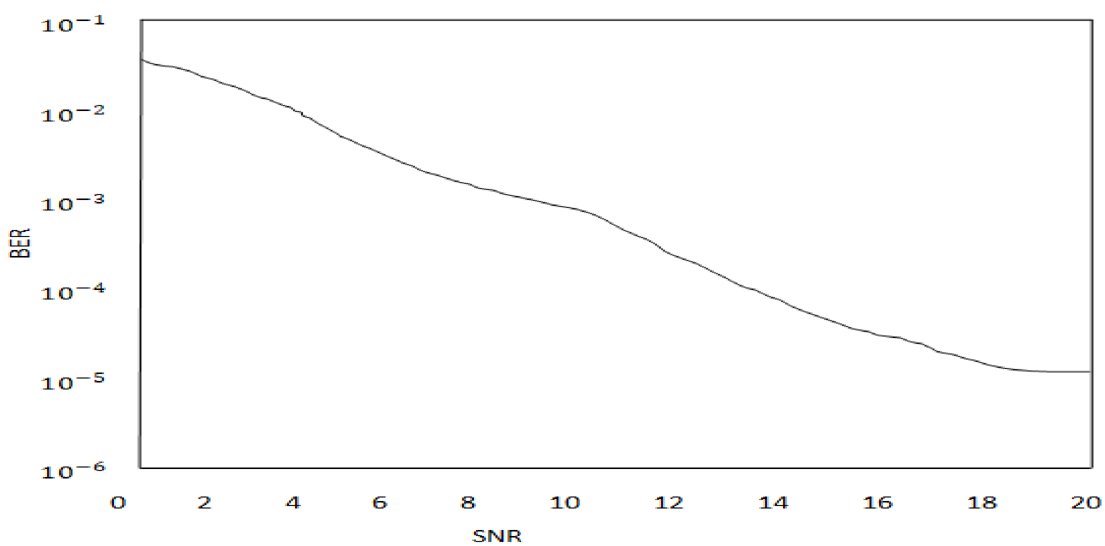


Figure 6.4- WHT Pre-coded LDPC FFT OFDM System

PARAMETERS	VALUES
Data Length	1000
Modulation	BPSK
CP Length	n/4
Encoding	LDPC
FFT Length	512
Pre-coding	WHT

Table 6.4- Parameters for WHT Pre-coded LDPC FFT OFDM

6.2 **Analysis**

The Results for the proposed methods clearly reflects the BER efficiency of the WHT pre-coded FFT OFDM system for the LDPC encoding. The LDPC codes provide the system with a BER performance even at low SNR values while the convolution coding does not provide the same. The DWT OFDM system provides the achievable BER with the help of pre-coding or making the LDPC codes not of much use.

The concern remains with the pre-coded DWT OFDM system with LDPC encoding technique for the further work.

CHAPTER 7

CONCLUSION AND FUTURE SCOPE

The presented research work, discussed about the various techniques to improve the BER rate in OFDM based WiMAX system. Two approaches have been implemented for the betterment of performance, namely encoding and time-frequency localization technique. The LDPC codes are constructed for broadband systems and then decoded with less complexity and soft decision making. The system model for WHT pre-coding is implemented.

The performance of BER in different channel models is analyzed with linear LDPC coding on FFT OFDM system and WHT OFDM, out of them the WHT OFDM has better performance in BER efficiency for both the Rician and Rayleigh channels. Better results are shown for the WHT OFDM for Rayleigh channel model. The described model for the LDPC FFT OFDM and LDPC WHT OFDM are then introduced with WHT pre-coding for further improvement in the BER rate.

The results depicts the pre-coding on the LDPC WHT OFDM are optimal then the LDPC FFT OFDM model. The complexity by the WHT pre-coding in the system is less comparative to the FFT pre-coding technique.

FUTURE SCOPE:

- To increase the efficiency of the system more advancement in encoding could be approached or some improvements can be done in the LDPC codes to make them less complex and more robust.
- The transformation techniques with some improvements in the Kernel matrix can make the signal processing much easy and efficient.
- The FFT OFDM system could also be reframed by the advanced signal processing technique blocks implementing the system for efficient BER, reduced PAPR and more feasible in deep fade conditions.

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