

Design of of DM with interpolated FIR Filter channel estimation based Fixed WIMAX System for Data and Image Transmission



Vasanth Kumar T R, K V Prasad

Abstract: *The growth in the today's wireless communication has led the demand of highly quality of service (QoS) in transmission. The existing telecommunication industries are providing the transmission with the speed of Kbps to Mbps while most of the industries are failed to better QoS. The significant technique called Orthogonal Frequency Division Multiplexing (OFDM) provides the better QoS but leads to high Cyclic Prefix (CP). The WIMAX (Worldwide Interoperability for Microwave Access) is a broadband wireless access technology that adopts the OFDM. This paper introduces OFDM based WIMAX system performance analysis using CP. The Simulink model is designed with 16 Quadrature Amplitude Modulation (QAM) with CP using MATLAB. The QAM scheme was examined for Bit Error Rate (BER) over Additive White Gaussian Noise (AWGN) channel and multipath Rayleigh fading channel that is subjected to the CP. The proposed OFDM system proved to possess a better BER for without fading channels. The OFDM data/image transmission includes AWGN and Rayleigh with different cyclic prefix values-1/4, 1/8 and 1/16 is plotted. The Cyclic prefix values are changing accordingly for transmitter and receiver. When Eb/No is 22db, the BER value 6.8e-5, 5.6e-5 and 5.8e-5 generated, for 1/4, 1/8 and 1/16 different cyclic prefix values respectively. Similarly, for image transmission proposed design achieves 19.94dB of PSNR value for SNR value of 7dB with respect to code rate 1/2 with 16-QAM*

Keywords : AWGN, BER, Cyclic Prefix (CP), OFDM.

I. INTRODUCTION

The demand for the application of digital video transmission over the internet is very high. The simple form of optimizing the cost of dedicated wires installation of wires over the same power lines used for supply electric currents in the home/office environments [1]. But this compact environment is not supportive for the communication and is necessary because of desired frequency selective transmission channel existence in both an impulsive noise and a background noise. The network branching structures and existence of various plugs subjected/connected or not for gadgets whose load impedances can changes to large extent and provides the

multipath propagation [3]. The outcomes of both the experimental and theoretical and experimental mechanisms for the applicability in this type of transmission were found in recent past which implements the standard modulation schemes. Over the research review found that the OFDM is a significantly robust technique for better transmission of digital data/image. The OFDM is an unit of frequency division multiplexing (FDM) scheme where every channel utilizes multiple sub-carriers on adjacent frequencies.

The subcarriers in the OFDM system are overlapping and which helps to enhance the spectral efficiency [4]. The overlapping of the adjacent channels can be interfere with each other but the OFDM system sub-carrier channels will be precisely orthogonal to each other and these subcarriers will be overlapping without interfere. Thus, the OFDM systems will be able to enhance the spectral efficiency without making interference with adjacent channel [2]. The OFDM scheme exhibits high sub channels or subcarriers which can be used in transmission of digital data/image. Every sub channels will be orthogonal to the every other sub-channel. These sub-channels will be closely spaced and narrow band. These sub-channels will be separated with a least distance which helps to achieve the higher spectral efficiency. The OFDM is mainly used to handle the effect of multipath propagation at the receiver. The multipath propagation leads to two effects like frequency selective fading (FSF) and Inter Symbolic Interference (ISI) [4]. The large number of narrow band sub-carriers of the OFDM gives necessary "flat" channels. Hence, the fading can be controlled through simple equalizing technique implementation for each channel. Also, the number of carriers gives the single carrier modulation having same data rates at a lower symbol rate. The symbol rate of every channels can falls to a point which makes every symbol longer than the channel's impulse response and it removes the ISI [1-3]. This paper presented the WIMAX based OFDM system performance evaluation using the CP implemented in 16QAM modulation scheme. The 16QAM is simulated by using MATLAB based Simulink. This paper is organized with following sections: Section II discusses the background of the concepts associated with OFDM and basic blocks involved in the WIMAX based OFDM system. Section III describes the existing researches in OFDM system. The problem statement considered in this paper is expressed in Section IV. The proposed system implementation is described in Section V. The results analysis is discussed in Section VI while conclusion of the paper is presented in Section VII.

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II. BACKGROUND

The present section revolves around the study of OFDM scheme which involves overview of OFDM, OFDM transmittance, OFDM receiver and issues concerning with OFDM.

A. Overview of OFDM

OFDM is a method which enables both multiplexing modulating techniques. OFDM system is based on the scheme of parallel information transmission that minimizes the extent of multipath fading and incorporates complex equalizers. The signal of Eureka 147 DAB is forwarded in the frame organization. Individually, all the frames are split into an integral count of modulated carriers that rely on the mode of transmission. Further, the modulation in the carriers is implemented utilizing the Differential Quadrature Phase Shift Keying (D-QPSK). The carriers used in the modulation are derived from the discrete Fourier Transform as the backbone of OFDM and uses a number of complex vector components defining the in-phase and quadrature-phase component [2]. The process made to execute by the aid of the symbol mapper of QPSK and block partitioner. Frequency interleaver is later is applied with differential modulation. It is implied to accommodate recovery of bits at the receiver section. All the OFDM carriers comprise of two bits of QPSK data which are encoded by the Gray code [3]. Hence, the COFDM procedure of signaling is described by the parameters of bandwidth, guard interval, frequency interleaving, and convolution encoding and modulation models.

The characteristics of the OFDM system are as follows:

- QAM is an example of mapping the data/image whereas few processing techniques are performed over interleaving data, source information, code for eliminating the errors and mapping of bits into symbols.
- Using the IFFT, modulation of symbols is achieved over orthogonal sub-carriers.
- At the duration of channel transmission, orthogonality is maintained. This is acquired by the addition of a cyclic prefix with an OFDM frame to be transmitted. Cyclic prefix has L last number of samples in the frame, which are replicated and positioned at the starting of the frame. The samples should last longer when compared to the response in channel impulse.
- Synchronization: the beginning of each frame can be detected by cyclic prefix. This is accomplished by the reason that the frames used in L for first and last time are same in count and share the property of correlation.
- FFT is used to demodulate the received data signal.
- Channel Equalization: The training sequence or the pilot symbols operate to determine the channel estimation.
- De-interleaving and Decoding

B. Orthogonality in OFDM

Typically, OFDM is kind of FDM along with carrier signals, that brings orthogonality among each other. Interferences such as cross talks and guard band requirement is eliminated as the sub-carriers selected in the design strictly obey the orthogonal property. This to a very large extent simplifies the

system design of both transmission and the reception sides. The sub-channels in FDM do not need separate filters [4]. The spacing of the sub-carriers in the orthogonal FDM systems is defined as,

$$\Delta f = \frac{k}{T_U} \text{ Hertz} \quad (1)$$

Where k is positive real number usually equal to 1 and T_U is a useful symbol time duration at the receiver's window side. Hence, as the sub-carriers represented with N, the total bandwidth is calculated to be $B \approx N \cdot \Delta f$ (Hz).

When parameters such as cost effectiveness, managing, and complex nature are considered wired network communication is highly infeasible, services are difficult to reach as the number of customers gradually increase. It not advisable to use wired communication for a long distance path and this problem can have resolved by making use of wireless communication. 'Wireless' is a term which is used by telecommunication devices where some amount of power is utilized to transfer data without including wires. In our routine life, the wireless communication plays a vital role. WiMAX has emerged as a prime choice for providing high rate of broadband access rendering connectivity throughout. The major concept for it to achieve high speed is OFDM [1-5]. WIMAX block diagram illustration is shown below:

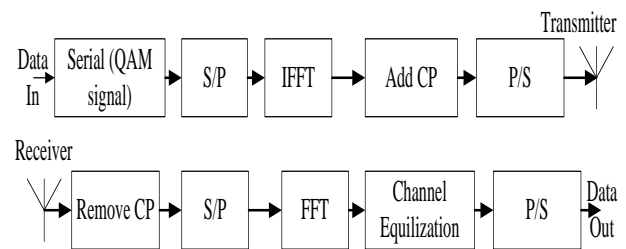


Fig.1. General WIMAX system

The major characteristics of WiMAX technology/IEEE 802.16 are:

- This exhibits the carrier frequency less than 11 GHz. For the current instant the frequency bands taken under consideration are 2.5GHz, 3.5GHz and 5.7GHz.
- The OFDM 802.16 is initially developed with the functionality of OFD< technique of transmission usually familiar for its high efficiency in its radio resource.
- Rate of data transmission: A value of 10Mbps is a reasonable one. Analysis have particularly reported ambitious values rising to 70Mb/s – 100 Mb/s. the mentioned values would hold good for a cell persisting smaller capacity and exceptional radio channel state.
- A distance until 20Km and lesser when to e integrated in indoor sights.

III. RELATED WORK

This unit gives the discussion of the various research towards the design and implementation of WIMAX based OFDM transmission system. The collaborative work of Dua and Yadav [6]

discussed the different digital modulation schemes like Phase Shift keying (PSK) and QAM over AWGN channel to perform the analysis of OFDM system performance with BER as performance matrix. The outcomes obtained by Simulation suggest the QAM scheme is significant with the ability of transmission with higher data rate than PSK scheme.

The same kind of research is found in Sood et al.

[7] which considered Binary PSK (BPSK) and Quadrature PSK (QPSK) for performance analysis with OFDM over Gama fading channel.

The work of Singh et al. [8] presented the performance analysis of the OFDM techniques in application in Long Term Evolution (LTE) technology. This work considered the Peak-to-Average Power Ratio (PAPR) minimization in OFDM system and compared the performance of two methods like Selective Mapping (SLM) and Partial Transmit Sequence (PTS) with PAPR reduction.

The significant research of Surekha et al. [9] illustrated the simulation system that implements the MATLAB based Simulink using AWGN. This research analyzed the performance with BER Vs Signal to Noise ratio (SNR). In this, the noise effect over AWGN channel was examined through Constellation diagrams. The obtained outcomes were compared with the simulated data using BER Tool. This tool helps to perform the QAM OFDM system characteristic analysis and declared the performance.

The implementation of OFDM transmission using wireless communications channels which resolves the multipath propagation issue [10]. The existing researches were focused on resolving the inherent challenges of OFDM that includes causes of CP extension, time and synchronization of frequency and alleviating effects of the frequency selective fading channel. The author has implemented the IEEE 802.16 WIMAX standard to resolve the above issues [11].

The significant work toward the optimization of performance in physical layer of WIMAX is described in Sharef et al. [12] which used a link level simulation. The WIMAX system (of IEEE 802.16e) composed of Multipath Rayleigh and AWGN channels and was designed by using MATLAB based Simulink. The impact over the system by CP, fading channel, Doppler shift was analyzed and examined. The outcome obtained from the simulation provides the improvement in channel estimation and system performance. Also, it is found that without channel estimation the system performance is decreases and leads to higher chances of errors.

Author Lahcen et al. [13] have illustrated a PAPR reduction method with slight variation in the phase. Also, an Multiple Input and Multiple Output (MIMO)-OFDM system is discussed with the PTS scheme consisting of solid state amplifier to reduce the PAPR.

Another work towards design of WIMAX physical layer was discussed Patidar et al [14] by using MATLAB based Simulink. The proposed WIMAX model is implemented to measure the performance of physical layer with BER as performance matrix in real time data (audio) communication under various modulation mechanisms, channel condition and encoding rate. The performance was analyzed with different scenarios like SNR level; demodulation of the received signal is performed and compared with original data. The final conclusion is conveyed with the plots of BER Vs SNR that gives the better idea of performance.

The similar work towards the design of a method to reduce the PAPR is found in Amit et al. [15] that use selective mapping

technique. In order to bring the more effectiveness in the PAPR reduction author have used the IFFT mechanisms with selective mapping technique. The modeling of the OFDM based system was done by using the MATLAB based Simulink with channel estimation and equalization sub system. The performance analysis was performed by considering the MIMO receivers over Rayleigh flat fading channel with channel estimation errors.

An interesting work of designing a hybrid PAPR method was described in Wang et al. [16] and this design is implemented over Filter Bank Multicarrier (FBMC) or OFDM based QAM systems FBMC/OQAM systems. This hybrid method was the combination of PTS and Tone Reservation (TR) techniques. The proposed method exploits the multi overlapped adjacent blocks to enhance the system. The performance was analyzed with Multi-level QAM by considering BER

IV. PROBLEM STATEMENT

A physical layer of fixed WIMAX standard is designed here using Simulink and its performance is evaluated under Rayleigh fading and AWGN noise effects. This system comprises an OFDM transceiver with Forward Error Correction and Channel estimation techniques. A channel is modeled with a combination of Rayleigh fading channel model and an AWGN noise model to introduce the fading and noise effects. The models are simulated by transmitting and receiving binary data and image through the OFDM system. The system performance is then measured with respect to BER and Peak signal to Noise ratio (PSNR). The BER determines the performance of the WIMAX physical layer and is measured by transmitting and receiving a binary data/image from the proposed wireless OFDM transceiver system. PSNR determines the transmission quality of the image transmitted and is measured by transmitting and receiving an image.

The OFDM transceiver design (in Fig.2) described here comprises the transmitter and receiver section which incorporates the forward error correction. The design intends to transmit a binary data/image to the receiver with a less error rate with fading and noise effects. To achieve this objective the OFDM modulator at the transmitter section is preceded with the Channel Encoder and Interleaver while that at the receiver section the demodulator is followed by the De-interleaver and Channel Decoder. A channel recovery block is added in the receiver section for estimating the amplitude and phase shifts caused by wireless channel. A pilot assisted channel estimation method is used for estimating the channel at pilot frequencies and interpolating for other frequencies. The channel recovery block helps in successful demodulation of the transmitted data/image.

The Channel encoder takes in the binary data/image and generates a code word using convolution coder from which error correction can be achieved. The interleaver assist in reducing the errors for burst error cases by performing the interleaving operation for the generated code word. A 16-bit QAM modulation involving the constellation mapping process is performed. The pilot carriers are inserted to the modulated data for channel estimation and an OFDM frame is constructed.

The OFDM frames are passed into IFFT block to convert it into an OFDM signal. A Cyclic prefix code is appended to the OFDM signal for reducing the interference caused by multipath fading and co-channel interferences.

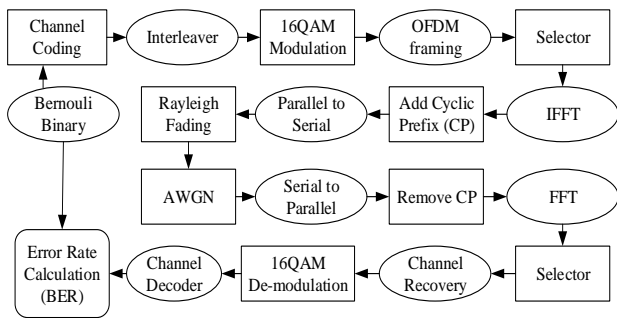


Fig 2. Architecture of proposed OFDM system

Transmitter: The input to the transmitter is a digital data/image which needs to be supplied by a binary generator. The designed system uses a Bernoulli binary generator which uses a Bernoulli random distribution for generating the binary numbers. A channel encoder block takes in the binary input data/image and generates a codeword based on the channel encoding scheme. A Convolution encoding scheme is utilized here for code word generation. The Channel Encoder designed here comprises three important blocks a randomizer, buffer and a convolution encoder. An Interleaver rearranges the coded symbols without omitting or repeating any symbol to avoid the effect of burst errors in the received signal. A random interleaver is used in the design which accepts the input vector and rearranges them in a random permutation. The Quadrature Amplitude Modulation block converts the input binary sequence into a complex signal. This complex signal represents one of the constellation point in a IQ plane. A 16-QAM block is designed here which takes in the interleaved sequence and maps them into one of the 16 constellation points. This block takes in the complex data and performs OFDM framing to generate an OFDM symbol. An OFDM symbol consists of data carriers and pilot carriers. The placement of the subcarriers depends on the Wireless standards chosen. For this design WIMAX standard is chosen using which the OFDM frame is constructed. This block is used to re-order the input samples. For the module of IFFT, 256 input samples are re-ordered to real and imaginary input samples. The time domain representation from the obtained OFDM symbol is generated using an IFFT operation considering each component of the OFDM symbol as a frequency representation of subcarrier. Hence the length of the IFFT block is chosen to be equal to the number of subcarriers. The IFFT ensures orthogonality of the subcarriers as well as provides a rapid and a parallel way of modulating the subcarriers. The Inter-symbol Interference effects can be minimized by extending the OFDM symbol period. One way to extend the symbol period is to add cyclic prefix code. The cyclic prefix code is the last portion of the OFDM symbol, which is appended to the start of the OFDM symbol. This block is used to convert the sampled based input into the frame based output at a comparatively higher rate. Buffer generates the sample based scaled output in the sequence which is converted to frame based sequence using a frame converter. This block is used to convert the sampled based

input into the frame based output at a comparatively higher rate. Buffer generates the sample based scaled output in the sequence which is converted to frame based sequence using a frame converter. Later, the transmitted samples are applied with Multipath Rayleigh Fading Channel for complex baseband signals. Then, AWGN block puts white Gaussian noise in the input signals. The input is either set to real or complex values.

Receiver: The receiver block starts with the serial to parallel converter taking in the OFDM signal that is affected by the channel response of fading and noise effects. The block takes in the channel samples and converts them in a parallel manner as frame based signals. The cyclic prefix code appended in the transmitter side will be removed from the OFDM signal. The 32 samples of cyclic prefix of the total 288 samples OFDM symbol is removed to obtain a 256 sample OFDM signal. A multi-port selector is used to remove the cyclic prefix code with indices to output in the range. This module transforms the time domain OFDM signal into frequency domain. A 256 point FFT is used for transforming 256 sample input OFDM signal to a frequency domain. The selector block is used to re-order the input samples. At the transmitter side 256 input samples are re-ordered to real and imaginary input samples. The number of input dimensions is set to 2. Index mode is selected to be "one-based." Therefore, "1" will be the first element and "2" will be considered as the second element. The Index option is selected to be Index vector (dialog). The original transmitted message is affected by the channel effects of Gaussian noise and fading. Hence channel estimation needs to be performed to obtain the channel response for recovering the transmitted message. A channel recovery block is introduced in the receiver which comprises of channel estimator block and channel recovered block to recover the transmitted QAM symbols. Channel estimation process demodulates the OFDM system using the technique of interpolation involved in it. Initially, it converts the FFT output into the frame based output. The modulated symbols are converted into bits using a QAM demodulator. The estimated constellation points act as inputs to the block which will get mapped to corresponding binary bits. A 16 QAM demodulator is used which maps each of the 16 points to a 4 bit binary sequence. The de-interleaver performs the reverse operation of interleaving. The arrangement of coded bits in de-interleaver will be the reverse arrangement as that of interleaver block. Channel decoder block is a part of forward error correction. The de-interleaved coded sequence is passed through a Channel decoder to decode the encoded data/image samples. The convolution encoded sequence is decoded here using a VITERBI decoder.

It calculates the error rate of the received data/image samples by comparing it with the delayed transmitted data/image samples. It has 3-elements in a block. These are 1.The error rate, 2. No. of errors detected and 3. Total No. of symbols compared. The design has the received delay to be set as = 420 (384+34+2).

V. INTERPOLATED FIR FILTER CHANNEL ESTIMATION

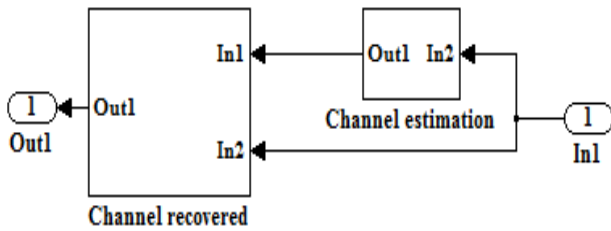


Fig.3. Interpolated FIR filter Channel estimation block

In Fig 3, a channel recovery block is added in the receiver section for estimating the amplitude and phase shifts caused by wireless channel. A pilot assisted channel estimation method is used for estimating the channel at pilot frequencies and interpolating for other frequencies. The channel recovery block helps in successful demodulation of the transmitted data.

The original transmitted message is affected by the channel effects of Gaussian noise and fading. Hence channel estimation needs to be performed to obtain the channel response for recovering the transmitted message. A channel recovery block is introduced in the receiver which comprises of channel estimator block and channel recovered block to recover the transmitted QAM symbols

Channel estimation process demodulates the OFDM system using the technique of interpolation involved in it

Following table.1, Shows the design specification for Fixed WIMAX standard

Table-I: Fixed WIMAX Design Specifications

Sampling time Ts	2.5x10 ⁻⁷ s
Channel bandwidth BW	4 Mhz
Bit rate Fb	16Mhz
Modulation	16-QAM
Eb/No	0-25db
FFT size	256
Pilot carriers	8
Data carriers	192
Nulls	56
Maximum number of symbols	1x10 ⁶
Total number of errors	500

Following table II gives the Raleigh parameters used in the design

Table -II: Multipath Raleigh fading Channel parameters

Max Doppler shift (f)	1-40Hz
Doppler spectrum type	Jakes
Path delay vector (s)	[0 10 ⁻⁹ 5x10 ⁻⁹]
Average Path gain vector (dB)	[0 -3 -6]

Table-III: AWGN Channel noise characteristics

Initial Read	1/73
Mode	Signal to Noise rate (Eb/No)
Eb/No(dB)	0-30
No. of bits/symbol	4
Input signal power	5x10 ⁻⁵
Symbol Period	1x10 ⁻⁴

VI. RESULTS ANALYSIS

This section the performance of the model designed is evaluated under two conditions of the channel 1) with fading and 2) without fading. The BER performance of the OFDM system for these two systems is analyzed for the above mentioned two conditions and compared with the theoretically generated BER values for the designed system. The theoretical values are obtained using BER calculation module present in MATLAB software.

The following Fig.4 and 5, shows the screenshot of MATLAB generated OFDM transceiver design for data and image transmission system respectively which involves the design process (as explained in Figure.2).

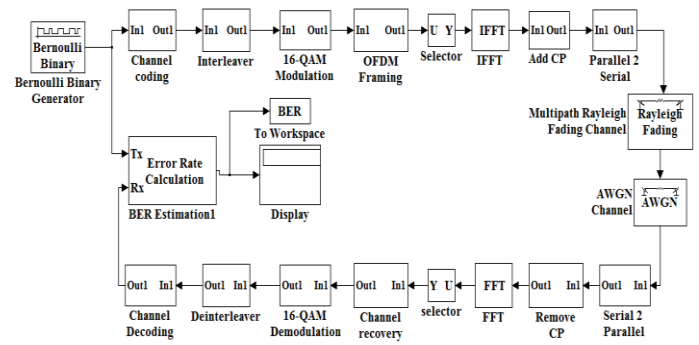


Fig.4. OFDM transceiver for data

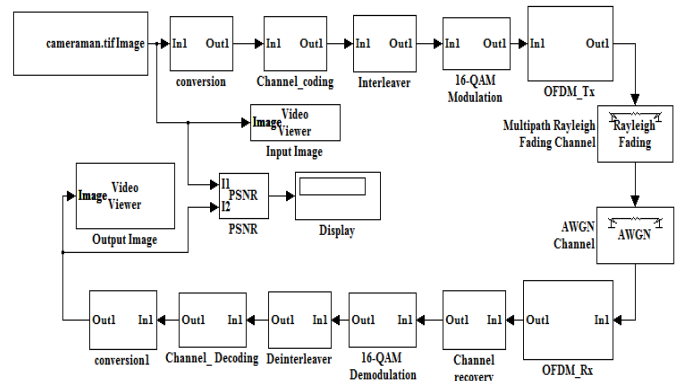


Fig.5. OFDM transceiver for image

The Fixed WIMAX data transmission without fading with different cyclic prefix values- 1/4, 1/8 and 1/16 shown in the Fig.6. The Cyclic prefix values are changing for transmitter and receiver. For Cyclic prefix 1/4 value means 16-bits, change the transmitter- [241:256] and Receiver [17:272] values accordingly.

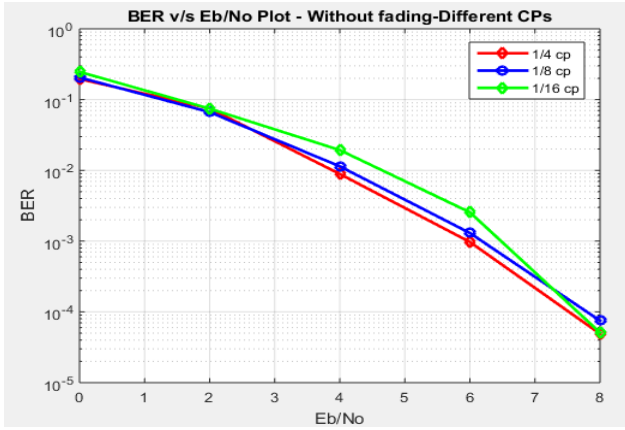


Fig 6: BER V/s EB/No Plot for Different Cyclic prefix (CP)'s without fading [Only AWGN]

Similarly, For Cyclic prefix 1/8 value means 32-bits, change the transmitter- [225:256] and Receiver [33:288] values. Similarly, For Cyclic prefix 1/16 value means 64-bits, change the transmitter- [193:256] and Receiver [65:320] values accordingly. When Eb/No is 8dB, Then the BER is 4.9×10^{-5} , 7.5×10^{-5} and 5.1×10^{-5} generated for 1/4, 1/8 and 1/16 different Cyclic prefix values respectively. So $\frac{1}{4}$ cyclic prefix is the 4.9×10^{-5} is BER for 8dB of EB/No. The Fixed WIMAX data transmission with fading includes AWGN and Rayleigh with different cyclic prefix values- 1/4, 1/8 and 1/16 shown in the Fig.7. The maximum Doppler shift is fixed to 1Hz. The Cyclic prefix values are changing accordingly for transmitter and receiver. When Eb/No is 22dB, then BER value 6.8×10^{-5} , 5.6×10^{-5} and 5.8×10^{-5} generated, for 1/4, 1/8 and 1/16 different Cyclic prefix values respectively. The cyclic prefix with 1/8 value i.e. 32bit prefix is better BER 5.6×10^{-5} value when 22dB.

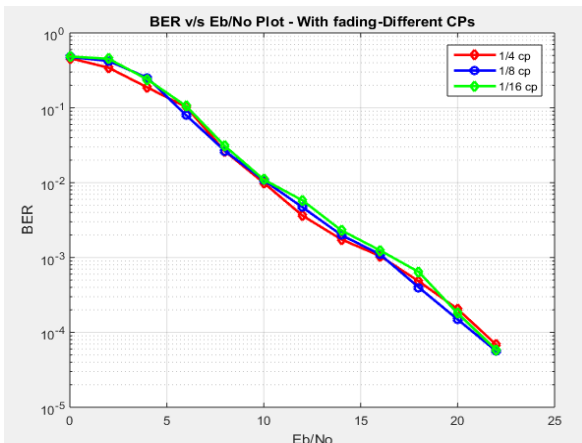


Fig 7: BER V/s EB/No Plot for Different Cyclic prefix (CP)'s with fading [AWGN +Rayleigh]

The transmission of 256x256 image is taken at different SNR value of 0, 5, and 16dB without fading [only AWGN] which is given in Fig 8.

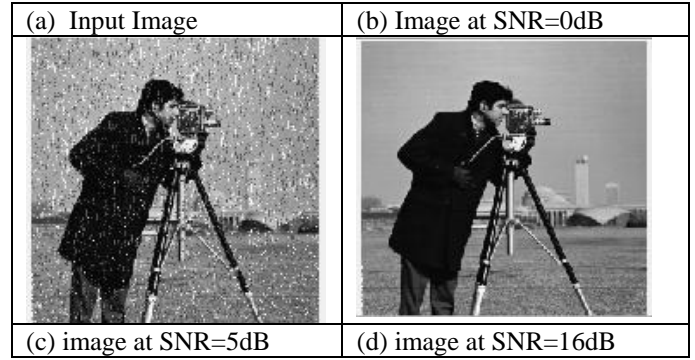
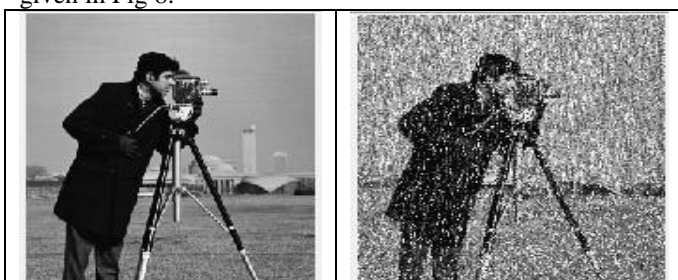


Fig.8: input image at different SNR without fading [only AWGN]

If only AWGN channel is used, the better image is generated when SNR is set to 16dB with cyclic prefix 1/8. The image PSNR value is generated is 27.08dB for 16dB SNR.



Fig.9: input image at different SNR with fading [AWGN and Rayleigh Channel]

Further same image of 256x256 is taken for transmission at different SNR value of 0, 5, and 18.5dB with fading [only AWGN + Rayleigh Channel] which is given in Fig 9. When Both AWGN and Rayleigh Channel is used, the better image is generated when SNR is set to 18.5db with cyclic prefix 1/8. The image PSNR value is generated is 27.08db for 18.5db SNR.

The SNR v/s PSNR plot for with and without fading is generated for the experimental image, when cyclic prefix value is 1/4, 1/8 and 1/16 set is as shown in the Fig.10.

The PSNR Value 27.08dB is generated, when SNR is set to 20db, 16db and 15dB without fading channel using different cyclic prefix 1/4, 1/8, and 1/16 respectively.

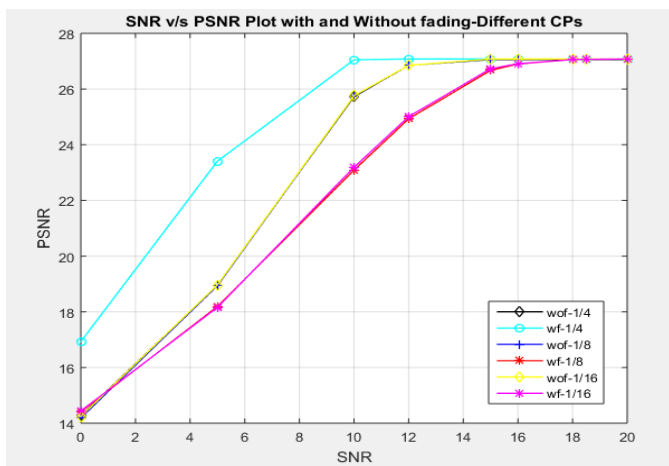


Fig.10: SNR v/s PSNR plot for with and without fading when cyclic prefix =1/4, 1/8 and 1/16

The comparison of PSNR Value when SNR =7dB with ref [17] as shown in the Table: IV. The PSNR value Improvement with respect to ref [17] is around 42%.

Table-IV: comparison of PSNR Value when SNR =7dB with ref [17]

Code rate-1/2 with 16-QAM	SNR(dB)	PSNR(dB)
Ref [17]	7	11.5
Proposed Design	7	19.94

VII. CONCLUSION

This paper presented the OFDM system performance evaluation using the CP implemented in 16QAM modulation scheme. The proposed OFDM system for data/image transmission in WIMAX system is evaluated. The OFDM is simulated by using MATLAB based Simulink. The schemes of simulation model were performed by Matlab software-simulation. The CP Values are changing accordingly for transmitter and receiver. The performance analysis for OFDM data transmission with different CP values with and without fading with respect to BER V/s Eb/No is plotted. When Eb/No is 22db, then BER value 6.8×10^{-5} , 5.6×10^{-5} and 5.8×10^{-5} generated, for 1/4, 1/8 and 1/16 different Cyclic prefix values respectively. The performance analysis for OFDM image transmission with different CP values with and without fading with respect to SNR V/s PSNR is plotted. The proposed design achieves 19.94dB of PSNR value for SNR value of 7dB with respect to code rate 1/2 with 16-QAM. The comparison of PSNR Value when SNR =7dB with ref [17] is done and found improvement around 42%., which it can improve the OFDM-based WIMAX system performance.

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