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A Review of BER analysis for MIMO-OFDM System for Pilot Based Channel Estimation

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Abstract— In this paper, review to improve the channel estimation accuracy in OFDM system, channel state information is required for signal detection at receiver and its accuracy affects the overall performance of system and it is essential to improve the channel estimation for more reliable communications. A multiple-input multiple-output (MIMO) communication system combined with the orthogonal frequency division multiplexing (OFDM) modulation technique can achieve reliable high data rate transmission over broadband wireless channels. The performance of MIMO-OFDM is evaluated on the basis of Bit Error Rate (BER). The paper is aimed at analyzing the BER performance of the MIMO-OFDM system for Pilot Based Channel along with a simulation channel. We show that in the MIMO-OFDM system for Pilot Based Channel Estimation BER decreases, as the signal to noise ration increases. Simulation results show that the proposed estimator is able to reduce the BER effectively at high SNR's and has a low computational complexity.

Keywords— MIMO- OFDM, Pilot Channel Estimation, BER

I. INTRODUCTION

Wireless communication, as the name suggests is wireless way of transmitting information from one place to another, is replacing most of the wired transmission of today's world. Research in the field of wireless communication is still a hot topic to discover new possibilities [1]. The goal of every research in this topic is to find more effective communication methods. Wireless communication helped the user to move freely without worrying about transfer of data. It dramatically changed the concept of information transfer in homes and in offices. Some of the key advantages gained by wireless communication are [2]:

1. **Efficiency Increase**- It improved communications that leads to faster transfer of information with in businesses and between partners/ customers.
2. **Always in reach** –There is no need to carry cables or adaptors in order to access some data in your office or home.
3. **Greater flexibility and mobility for users** –Workers in an office don't need to sit on dedicated PCs. They can be wirelessly networked together.
4. **Reduced costs** – Compared to wired communication, wireless systems are usually cheaper to use, easy to install and maintain.

The basic building blocks of a typical wireless communication system are shown in Figure 1.1.

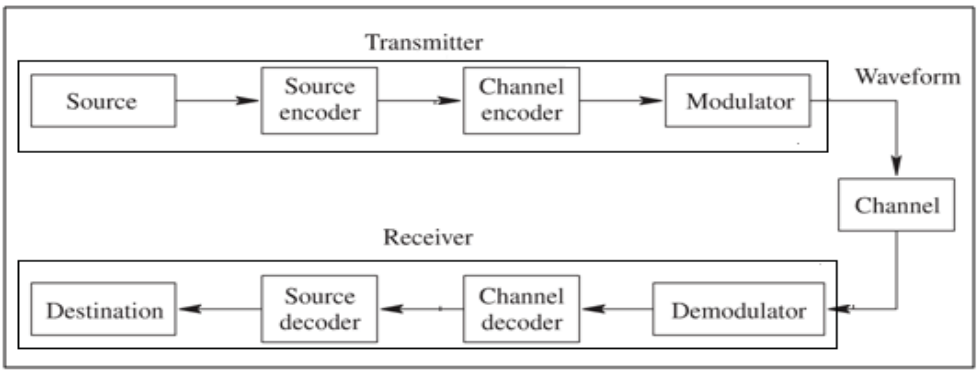


Figure 1.1: Wireless Communication System

In the figure the source block is the source of information that we need to transmit from one place to another. It can be a voltage signal, a voice signal or anything else. This information is first converted to digital data and then source encoded. Source encoding reduces the amount of the data present in the signal to reduce the bandwidth required to transmit the associated data. Then the data proceeds to channel encoder block, which is responsible for adding extra bits in the data to help correcting errors inflicted to the data due to fading and noise. Our thesis contains three techniques for channel encoding that will be explained in later chapters. The modulator modulates the message signal on the transmission frequency so that the signal is ready for transmission.

The OFDM (Orthogonal Frequency Division Multiplexing) is becoming a very popular multicarrier modulation technique for transmission of signals over wireless channels. OFDM divides the high-rate stream into parallel lower rate data and hence prolongs the symbol duration, thus helping to eliminate Inter Symbol Interference (ISI). It also allows the bandwidth of subcarriers to overlap without Inter Carrier Interference (ICI) as long as the modulated carriers are orthogonal.

MIMO-OFDM (multiple input multiple output orthogonal frequency division multiplexing), a new wireless broadband technology, has gained great popularity for its capability of high rate transmission and its robustness against multi-path fading and other channel impairments. The arrangement of multiple antennas at the transition end and reception end results increase in the diversity gain refers the quality of signal and multiplexing gain refers the transmission capacity.

II. MIMO- OFDM SYSTEM

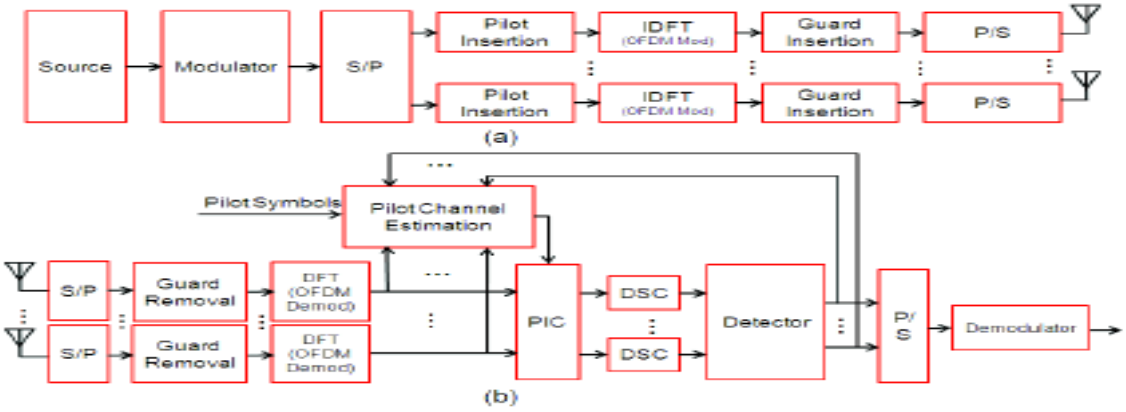


Fig. 1. Block diagram of the OFDM system, (a): Transmitter, (b): Receiver

Fig. 1 depicts a high level block diagram of the MIMO- OFDM system.

We consider MIMO–OFDM systems with two transmit antennas and two receive antennas. The total number of subcarriers is N. Basically, the MIMO-OFDM transmitter has N_t parallel transmission paths which are very similar to the single antenna OFDM system, each branch performing serial-to-

parallel conversion, pilot insertion, N-point IDFT and cyclic extension before the final TX signals are up-converted to RF and transmitted. It is worth noting that the channel encoder and the digital modulation, in some spatial multiplexing systems, can also be done per branch, where the modulated signals are then space-time coded using the Alamouti algorithm [3] before transmitting from multiple antennas [4] not necessarily implemented jointly over all the $N_t$branches. Subsequently at the receiver, the CP is removed and N-point DFT is performed per receiver branch. Subsequent the DFT block, the guard interval, which is chosen to be greater than the delay spread and contains the cyclically extended part of the OFDM symbol for eliminating inter-carrier interference, is inserted to avoid inter-symbol interference. Next, the transmitted symbol per TX antenna is combined and outputted for the subsequent operations like digital demodulation and decoding. Finally all the input binary data are recovered with certain BER.

III. ADVANTAGES OF OFDM

OFDM has several advantages that make it a possible alternative for CDMA and other future wireless technologies. Some of the main advantages are discussed below.

3.1. Multipath Delay Spread Tolerance

OFDM is immune to multi-path delay spread, which causes ISI in wireless networks. Making the symbol duration larger reduces the effect of delay spread. It is done by converting high rate data signal into lower rate data signal. ISI is eliminated by the introduction of guard time.

3.2. Immunity to Frequency Selective Fading Channels

For single carrier modulation techniques, complex equalization techniques are required if channel imposes frequency selective fading, while in OFDM the bandwidth is split in many orthogonal narrow flat fading subcarriers. Hence it can be assumed that the subcarriers experience flat fading only, though the channel gain/phase associated with the subcarriers may vary. In the receiver, each subcarrier just needs to be weighted according to the channel gain/phase encountered by it. Even if some subcarriers are completely lost due to fading, the user data can be recovered by proper coding and interleaving at the transmitter.

3.3 Efficient Modulation and Demodulation

Modulation and demodulation of the sub-carriers is done using IFFT and FFT methods respectively, which are computationally efficient. The modulation and demodulation in digital domain avoids the need of high frequency stable oscillators.

IV. ON THE OTHER HAND, OFDM ALSO HAS SOME DISADVANTAGES

4.1 Frequency offsets and phase noise sensitivity. Phase noise is especially acute at high carrier frequencies.
4.2 Peak to average power ratio (PAPR) is high, which reduce the power efficiency of the RF amplifier.
4.3 The OFDM signal has a noise like amplitude with a very large dynamic range, therefore it requires RF power amplifiers with a high peak to average power ratio.
4.4 It is more sensitive to carrier frequency offset and drift than single carrier systems are due to leakage of the DFT.

V. LITERATURE SURVEY

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

Heung-GyoonRyuet. al.(2005) presented a paper "An Improved ICI Reduction Method in OFDM Communication System"[5] analyzed the system performance of the OFDM system when phase noise exists. The data conjugate method is studied to compare with the original OFDM, OFDM with convolution coding and the data-conversion method.

1) CPE, ICI and CIR caused by phase noise are analyzed in the data-conjugate method and compared with other methods. From the analysis, the CPE of the data-conjugate method is shown to be zero when channel has flat characteristic.

2) BERs are found by the computer simulation to compare the system performance affected by phase noise in the four type systems. As results, the performance penalty can be reduced when two kinds of ICI self-cancellation method are used. Especially, the data-conjugate method brings the more significant improvement than the data-conversion method.

Overall, with respect to the PAPR and BER, the OFDM system of the data-conjugate method shows the best performances compared with the original OFDM, OFDM with convolution coding and the data-conversion method. So, data conjugate ICI self-cancellation method may be very useful to the multi-carrier system of the high transmission quality.

Jianqiang He (2008) presented a paper "MMSE Interference Suppression in MIMO Frequency Selective and Time-Varying Fading Channels"[6].The work is been implemented under the fading channels. The work includes the analysis on ICI and the ISI. A joint analysis is performed on these two type of interference and the kalman filter is been implemented in this paper. The works also include the use of feedback equilizer to perform the noise reduction along with channel estimation for uncertain interference over the channel. The time and frequency based analysis is used by the researcher.

Jia TU (2008) presented a paper "Turbo Equalization based on a New Kalman Filter for OFDM over Doubly-Selective Channels"[7]. The approach is implemented for the fading channel and the analysis is performed for both the time and frequency selective data transmission. In this work a turbo equilized is suggested with kalman filter. The Kalman filter performed the statistical analysis and the ICI reduction is been performed by using the turbo equalizer. The results are been performed in terms of time delay and complexity analysis.

HussinHijazi (2008) presented a paper "OFDM High Speed Channel Complex Gains Estimation Using Kalman Filter and QR-Detector"[8]. The author has implemented a delay based analysis for multipath channel under the fading constraint. The kalman filter analysis is performed to noise estimation and to perform the ICI reduction the QR decomposition is been implemented. The simulation results are based on High Doppler spreads.

Shih-Kang Wang (2009) presented a paper "Pilot-Aided Channel Estimation Methods for ICI Reduction in Mobile OFDM Systems"[9]. The ICI reduction algorithm includes the channel impulse response. The author has used the channel impulse response to control the ICI over the channel. The work is analysed under the frequency and time domain approach. To perform the noise analysis kalman filter was used by the researcher. The BER ratio analysis is used to present the final results.

Jaechan Lim et. al. (2009) presented a paper "Inter-Carrier Interference Estimation in OFDM Systems With Unknown Noise Distributions"[10]. The ICI estimation and reduction performed by using two main approaches called Kalman Filter approach and the Carrier frequency offset. The statistical approach was presented by the author to perform the analysis estimation as well as noise reduction over the channel.

Kandarpakumar (2010) presented a paper "MIMO Channel Modeling using Temporal Artificial Neural Network (ANN) Architectures"[11]. The researcher adept the statistical nature of the network and combined it with neural to perform the channel estimation as well as the symbol recovery. The work is based on multi layered perceptron architecture. In this work author consider the indoor network and modal the channel under slow fading conditions.

Hussein Hijazi (2010) presented a paper "Joint Data QR-Detection and Kalman Estimation for OFDM Time-Varying Rayleigh Channel Complex Gains"[12]. The work is based on the time domain and the delay analysis is been performed for multipath communication. The polynomial coefficient is been used for The channel matrix is been presented with ICI for QR decomposition for the channel matrix .

Jin Whan Kang" (2011) presented a paper "Adaptive Modulation and Coding for MIMO-OFDM Systems using LMS Channel Prediction and CQI Table Adaptation"[13]. In this author performed a work on channel prediction based on CQI table adaptation. The work includes the effective modulation and coding scheme for channel prediction in OFDM system. The channel is been analyze based on statistical parameters and the different filters are being implemented to perform the noise analysis. In this work the analysis is performed on channel quality and based on this an adaptive utilization table is generated to get the verification about the channel limits under different parameters. These parameters include the error reduction under wiener filter.

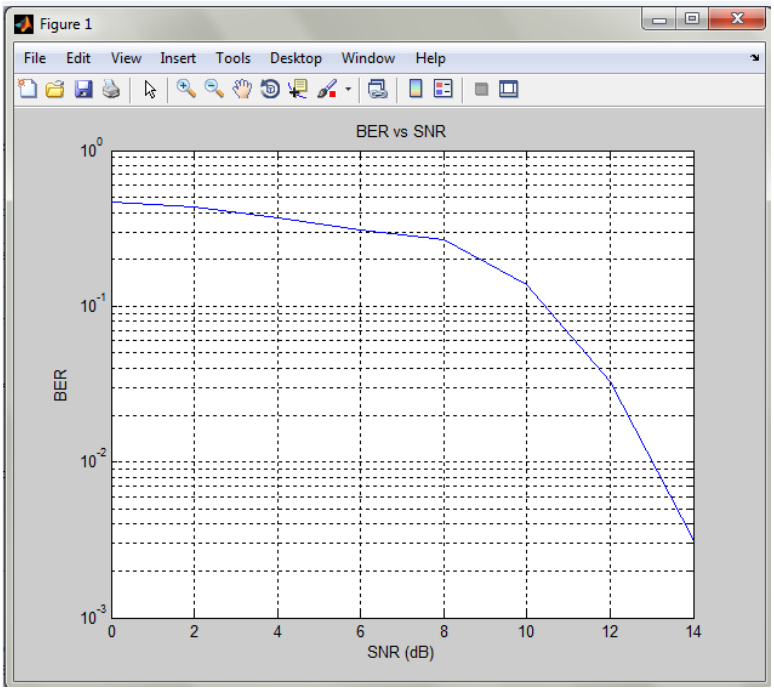
MitaleeAgrawal(2011) presented a paper "BER analysis for MIMO OFDM System for AWGN & Rayleigh Fading Channel"[14]. The work is performed for fading channel and Gaussian noise. The author analyzes the work under different modulation schemes. The paper is aimed at analyzing the BER performance of the MIMO (Multi-Input Multi-Output) OFDM system for AWGN (Additive White Gaussian Noise) Channel, Rayleigh Fading Channel along with a simulation channel using different modulation technique. This paper is my base paper in base paper the work is performed for BER analysis. The work is extended in two ways first to analyze the BER and perform ICI reduction respectively second Kalman filter is implemented for BER analysis.

VII. SOFTWARE TOOLS

Software is used here,That is **MATLAB** (R2012a).
The MATLAB® high-performance language for technical computing integrates computation, visualization, and programming in an easy-to-use environment where problems and solutions are expressed in familiar mathematical notation.**MATLAB** (**mat**rix **lab**oratory) is a multi-paradigm numerical computing environment and fourth-generation programming language. Developed by MathWorks, MATLAB allows matrix manipulations, plotting of functions and data, implementation ofalgorithms, creation of user interfaces, and interfacing with programs written in other languages, including C, C++, Java, and Fortran.Although MATLAB is intended primarily for numerical computing, an optional toolbox uses the MuPAD symbolic engine, allowing access to symbolic computing capabilities. An additional package, Simulink, adds graphical multi-domain simulation and Model-Based Design for dynamic and embedded systems.

VIII. SIMULATION RESULTS

Figure.1 Bit Error Rate v/s Signal-to-Noise ratio.



In this present work, the result analysis will be done in terms of reduction of BER under different SNR values. The result driven from the system will be in the form of graph.

1. The x-axis of graph will represent the Different SNR value.
2. The y axis of graph wi1ll represent the BER rate.
3. The comparison between the standard MIMO and proposed work will be drawn.

IX. CONCLUSION

Results analysis shows that the presence of Pilot channel estimation very vital role in improving the BER performance of the MIMO-OFDM system. The performance of the system enhanced to significant extent on suitable value of Pilot channel estimation along with suitable modulation technique. However, there is further possibility of improving the BER performance by developing new technique to compensate ISI effect, as the Pilot channel insertion affects system efficiency due to increased overhead.

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