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Channel Estimation Analysis in MIMO OFDM System over Fading Channel

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Abstract— **Multiple Input Multiple Output-Orthogonal Frequency Division Multiplexing (MIMO-OFDM) systems play a vital role in the channel estimation. The wireless channel suffers from impairments like fading and interference. Technologies that achieved above requirements are Multiple Input Multiple Output (MIMO) and Orthogonal Frequency Division Multiplexing (OFDM). Channel impairments must be mitigated at the receiver by using channel estimation techniques. In this paper, BER performance improvements of MIMO-OFDM systems using different techniques such as Least Square (LS), Minimum mean square error (MMSE) are implemented and compared. Work is carried out in Mat lab under fading channels.**

Keywords—**Channel Estimation, Least square (LS), Minimum Mean square error, MIMO-OFDM**

I. INTRODUCTION

In the communication system, the signals are transmitted using several techniques, such as Frequency Division Multiple Access (FDMA), Time Division Multiple Access (TDMA) and Code Division Multiple Access (CDMA). The two different characteristic networks used in the communication system are wired and wireless. In Wired technology, the transmission and its carrier waves are limited within the medium and a channel is formed for communication. The Wireless communication is a robust data communication system, which is used as an extension to or as an alternative for wired communication. MIMO technology is a most significant method, which is employed to improve the signal to noise ratio for wireless technologies. MIMO wireless technology increases the spectral efficiency through spatial multiplexing gain, and due diversity gain, it enhances the link reliability. MIMO systems are a natural extension of developments in antenna array communication. Combining OFDM with MIMO can increase the diversity gain as well as improve the system capacity on time-variant and frequency selective channels. OFDM is a promising technology for achieving high data rates, which is a digital multi-carrier modulation scheme. OFDM is employed in several OFDM based transmission standards, such as the digital audio broadcasting (DAB), digital video broadcasting (DVB), worldwide interoperability for microwave access (WIMAX), Integrated Services Digital Broadcasting Terrestrial (ISDB-T) and Digital Terrestrial/Television Multimedia Broadcasting (DTMB) and high-speed wireless broadband local area networks (WLAN). In wireless access systems with fading in the channels of signal distribution like Wi-MAX systems, receiving and transmission diversity. Channel estimation is an important task in wireless communication systems. The channel estimation can be done in two ways: (1) placing the pilot tones into all of the sub carriers of OFDM symbols with a certain period, or (2) placing the pilot tones into each OFDM symbol. The data received is in the form of MIMO Channel Matrix. This channel matrix can be determined by using statistical, measurement based or site-specific deterministic techniques. In this paper, we present a comprehensive review of extremely important researches available in the literature for channel estimation in MIMO-OFDM system, using different methods. The reviewed researches are classified according to the type of channel estimation methods.

II. SYSTEM MODEL

Multiple-Input Multiple-Output System (MIMO) MIMO technology is also utilized to maximize the signal to noise ratio for wireless technologies, particularly in mobile Wi MAX where there is a non-line-of-site situation and it needs to be adjustable to change the signal to noise ratio. It is clearly exposed that MIMO systems has the potential to provide higher capacity than the single input single-output (SISO) counterparts. The advantages of MIMO communication, which uses the physical channel between several transmit and receive antennas, are currently receiving much attention. Moreover, the system capacity can be considerably improved if multiple transmit and receive antennas are used to generate MIMO channels.

OFDM is widely recognized as a robust modulation technique for wireless communication. OFDM is a promising multi carrier transmission technique for the broadband wireless communication systems, which offers an efficient way to control the multipath and frequency selective fading without complex equalization. OFDM/QAM systems are efficient for multipath channels because the cyclically prefixed guard interval is included between consequent symbols to remove inter symbol interference (ISI).

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.

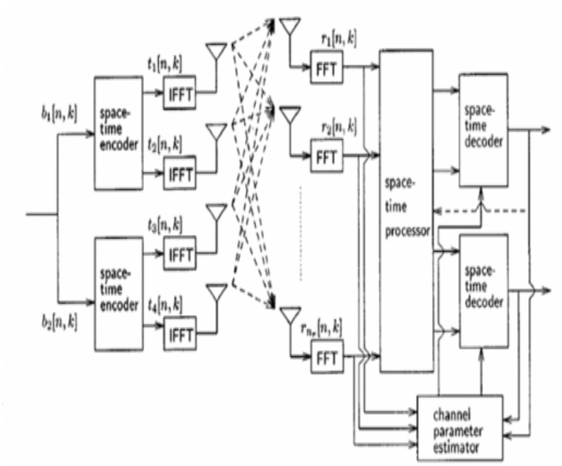

Fig 1: Block Diagram of MIMO OFDM

The total number of subcarriers is N. Basically, the MIMO-OFDM transmitter has parallel transmission paths which are very similar to the single antenna OFDM system, each branch performing serial-to-parallel conversion, pilot insertion, N-point IFFT and cyclic extension before the final TX signals are up-converted to RF and transmitted. The channel encoder and the digital modulation can be done per branch. Subsequently at the receiver, the CP is removed and N-point FFT is performed per receiver branch. Next, the transmitted symbol per TX antenna is combined and outputted for the subsequent operations like digital modulation and decoding. Finally all the input binary data are recovered with certain BER.

Channel estimation is an important task in coherent communication systems. As well as it is a major issue for coherent OFDM systems. As compared to the SISO systems, channel estimation is more difficult because of the increased number of channels to be estimated. Based on the signals correlation, the channel estimation method is developed. Estimation of the signal amplitude and the propagation delay of each user are performed. Also the effect of channel estimation is utilized in diversity combination and optimization of the receiver performance. The quality of the channel estimation method has a severe impact on the overall Bit Error Rate (BER) performance of the receiver

III. CHANNEL MODEL

The profile of received signal can be obtained from that of the transmitted signal if we have a model of the medium between the two. This model of the medium is called channel model. The estimation of the channel is done using the following channel models namely Rayleigh and Rician. It is done by implementing LS, MMSE estimation algorithms.

Rayleigh Channel Model: In mobile radio channels, the Rayleigh distribution is commonly used to describe the statistical time varying nature of the received envelope of a flat fading signal, or the envelope of an individual multipath component. It is well known that the envelope of the sum of two quadrature. Gaussian noise signals obeys a Rayleigh distribution. Signal weakening can cause the main component not to be noticed among the multipath components, originating Rayleigh model. Rayleigh fading is a reasonable model when there are many objects in the environment that scatter the radio signal before it arrives at the receiver. The central limit theorem holds that, if there is sufficiently much scatter, the channel impulse response will be well-modeled as a Gaussian process irrespective of the distribution of the individual components. If there is no dominant component to the scatter, then such a process will have zero mean and phase evenly distributed between 0 and 2π radians. The envelope of the channel response will therefore be Rayleigh distributed.

Rayleigh fading is the specialized model for stochastic fading when there is no line of sight signal, and is sometimes considered as a special case of the more generalized concept of Rician fading. In Rayleigh fading, the amplitude gain is characterized by a Rayleigh distribution. The requirement that there be many scatters present means that Rayleigh fading can be a useful model in heavily built-up city centers where there is no line of sight between the transmitter and receiver and many buildings and other objects attenuate, reflect, refract and diffract the signal.

***Rician Channel Model**:* When there is a dominant stationary signal component present, such as a line-of-sight propagation path, the small scale fading envelope distribution is Rician. In such a situation, random multipath components arriving at different angles are superimposed on a stationary dominant signal. At the output of an envelope detector, this has the effect of adding a dc component to the random multipath.

Rayleigh channel model is a stochastic model for radio propagation anomaly caused by partial cancellation of a radio signal by itself the signal arrives at the receiver by several different paths multipath interference and at least one of the paths is changing. Rician fading occurs when one of the paths, typically a line of sight signal, is much stronger than the others. In Rician fading, the amplitude gain is characterized by a Rician distribution.

IV. CHANNEL ESTIMATION ALGORITHMS

a. Least Square Algorithm

It is a standard approach to the approximate solution of over determined system. It means that the overall solution minimizes the sum of the squares of the errors.

b. Minimum mean square Error Algorithm

MMSE estimator describes the approach which minimizes the MSE, which is a common means of estimator quality.

The MIMO-OFDM is an efficient wireless system. It has the efficient use of available bandwidth since the sub channels are overlapping. The performance of the MIMO OFDM system is optimized with minimum bit error rate. OFDM with multiple transmit and receive antennas form a MIMO system to increase system capacity The same algorithm can be applied to the Rayleigh and Rician channel models. Then comparing the BER value for different low and high Eb/No value are implemented by using LS, MMSE algorithm.

In digital transmission, the number of bit errors is the number of received bits of a data stream over a communication channel that has been altered due to noise, interference, distortion or bit synchronization errors. The bit error rate or bit error ratio (BER) is the number of bit errors divided by the total number of transferred bits during a studied time interval.

The bit error rate or bit error ratio (BER) is defined as the rate at which errors occur in a transmission system during a studied time interval. BER is a unit less quantity.

c. Steps To Calculate BER for Channel

Step 1: Initialize the various parameters such as number of subcarriers, number of pilots, guard interval.
Step 2: Assume SNR Value.
Step 3: Generate OFDM symbols for random input data.
Step 4: Modulate the encoded data by BPSK modulation technique.
Step 5: For AWGN channel, add the complex Gaussian noise to the data.
Step 6: Take variance of noise and add data to the noise.
Step 7: The channel is estimated by evaluating the mean square error (MSE) and Bit Error Rate (BER) using LS, MMSE algorithms.
Step 8: Finally the received data is demodulated.
Step 9: Plot the graph for MSE and BER end the process.

Table 1 show the parameters of OFDM, which is used in our project.

Table 1: OFDM Parameter

OFDM parameters	Specification
MIMO-OFDM system	2*2, 2*1, 1*2
Number of bits processed	1500
Number of subcarriers	52
Number of data subcarriers	48
Modulation type	QAM, QPSK
Frame size	100
Number of bits in each frame	96
FFT size	64 points
Cyclic extension	0-25
Bandwidth	20Mhz
Channel	Rayleigh, Rician

V. RESULT ANALYSIS

The simulation analysis of algorithms for different modulations, different fading channels in MIMO OFDM systems is as shown from Fig 2 to Fig 5.

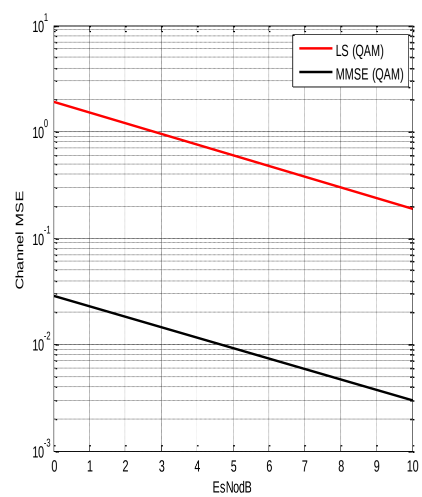

Fig 2(a): Analysis of QAM for LS and MMSE Algorithm

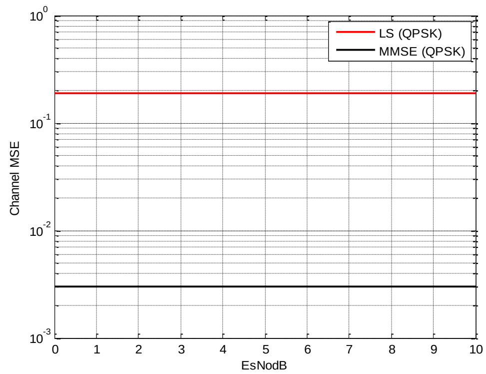

Fig 2(b): Analysis of QPSK for LS and MMSE Algorithm

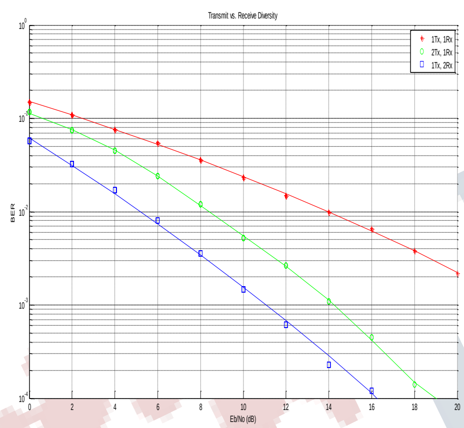

Fig 3: Analysis of MIMO System

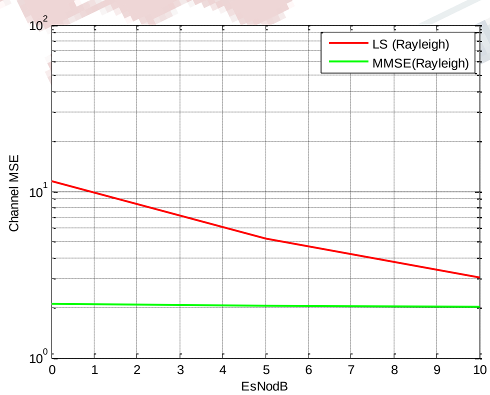

Fig 4: Analysis of best algorithm for Rayleigh channel

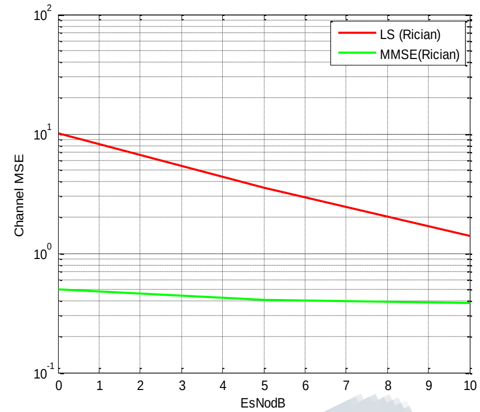

Fig 5: Analysis of best algorithm for ricianchannel

Consider fig 2(a) and 2(b) we can nalyze the best modulation technique in between QAM and QPSK for both the algorithms. QAM results decrease in MMSE as SNR increasesbut QPSK is Static. Fig 3 shows the basic analysis of MIMO system, for multiple receiver shows less BER. Fig 4 and Fig 5 shows the less mean square error for MMSE algorithm compare to LS algorithm.

VI. CONCLUSION

Figure 4 and 5 concludes that forMMSE algorithm, as SNR increases the MSE decreases.The outcome relatively with less error results for higher SNR. Finally to reduce MSE using LS and MMSE algorithm is analyzed and MMSE algorithm gives the better result compared to LS algorithm for both Rician and Rayleigh Channel using MIMO system. So MMSE gives better estimation over fading channel.

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