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Performance of AWGN Channel Using Least Square Modified Algorithm

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Abstract: MIMO-OFDM is commonly used communication system due to its high transmission rate and robustness against multipath fading. In MIMO-OFDM, channel estimation plays a major role. It refers to estimation of transmitted signal bits using the corresponding received signal bits. Among the different channel estimation methods, Least Square (LS), Least Square-Modified (LS-Mod) and Minimum Mean Square Error (MMSE) methods are commonly used. In this project, we use 16QAM Modulation and AWGN channel model are implementing by using LS, LS-Modified and MMSE algorithms. In LS estimation, procedure is simple but it has high Mean Square Error. In low SNR, MMSE is better than that of LS, but its main problem is its high computational complexity and LS-Modified is considered to be the best among the three channel estimation methods. The system is simulated in MATLAB and analysed in terms of Bit Error Rate with Signal to Noise Ratio.

Key words: MIMO-OFDM, LS, MMSE, LS-MOD

I. INTRODUCTION

Wireless communication is the transfer of information between two or more points that are not connected by an electrical conductor while wireless operations permit services, such as long-range communications, that are impossible or impractical to implement with the use of wires. The term is commonly used in the telecommunications industry to refer to telecommunications systems which is to transfer information without the use of wires over both short and long distances. Wireless networking the various types of unlicensed 2.4 GHz WI-Fi devices used to meet many needs [1].

A wireless transmission method is a logical choice to network a LAN segment that must frequently change locations are used tomeet many needs. The term "wireless" came into public use to refer to a radio receiver or transceiver, the term is used to describe modern wireless connections such as in cellular networks and wireless broadband Internet.

In MIMO-OFDM channel estimation plays an important role. It refers to the estimation of transmitted signal bits using the corresponding received signal bits. Here, three channel models namely AWGN, Rayleigh and Rician are estimated. It is implemented by using three algorithms namely Least Square (LS), Minimum Mean Square Error (MMSE), Least Square Modified (LS-Mod).The system is simulated in MATLAB and analysed in terms of Bit Error Rate (BER) with Signal to Noise Ratio (SNR).

In LS algorithm, estimation procedure is simple but it has high mean square error (MSE).In low SNR, MMSE is better than that of LS, but its main problem is its high computational complexity. In high SNR LS is better than that of MMSE algorithm. LS-Modified is suitable for both low and high values of SNR Wireless phones use radio waves to enable their users to make phone calls from many locations worldwide. These can be used within the range of telephone required to transmit and receive the radio signals from these instruments. Wi-Fi has become de facto standard for access in private homes, within offices, and at public hotspot. Wireless Mobile Phone Remote Controls, DSRC are used in short-range point-to-point communication [2]. Wi-Fi, WMAN and WiMax used under wireless network category.

II. THEORY OF MIMO-OFDM

As shown in fig 1, MIMO is the use of multiple antennas at both the transmitter and receiver to improve communication performance. It is one of several forms of smart antenna technology. The terms input and output refer to the radio channel carrying the signal, along with the devices having antennas. MIMO technology has attracted attention in wireless communications, because it offers significant increases in data throughput and link range without additional bandwidth or increased transmit power. It achieves this goal by spreading the same total transmit power over the antennas to achieve an array gain that improves the spectral efficiency or to achieve a diversity gain that improves the link reliability [4]

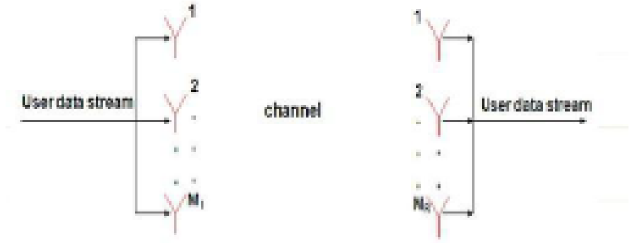

Fig 1. MIMO

III. CHANNEL ESTIMATION

In computer networking, a communication channel, or channel, refers either to a physical transmission medium such as a wire, or to a logical connection over a multiplexed medium such as a radio channel. A channel is used to convey the information signal, for example a digital bit stream from one or several senders to one or several receivers. A channel has a certain capacity for transmitting information, often measured by its bandwidth in Hz or its data rate in bit per second. The term channel refers to the medium between the transmitting antenna and the receiving antenna[6] The characteristics of wireless signal changes as it travels from the transmitter antenna to the receiver antenna. These characteristics depend upon the distance between the two antennas, the paths taken by the signal and the environment around the path. In general, the power profile of the received signal can be obtained by convolving the power profile of the transmitted signal with the impulse response of the channel. Convolution in time domain is equivalent to multiplication in the frequency domain. Therefore, the transmitted signal x, after propagation through the channel becomes y[7]

$$y(f)=H(f)x(f)+n(f) \quad (2)$$

Here H(f) is channel response, and n(f) is the noise. Note that x, y, H, and n are all functions of the signal frequency f. The objects located around the path of the wireless signal reflect the signal. Some of these reflected waves are also received at the receiver. Since each of these reflected signals takes a different path, it has a different amplitude and phase. Channel estimation can be performed in three ways. They are training-based channel estimation, blind channel estimation and semi blind channel estimation [8]. In training-based channel estimation, known symbols are transmitted specifically to aid the receiver's channel estimation algorithms [9]. Here, training symbols or pilot tone that are known a priori to the receiver, are multiplexed along with the data stream for channel estimation. In a blind channel-estimation method, the receiver must determine the channel without the aid of known symbols. The blind channel estimation is carried out by evaluating the statistical information of the channel and certain properties of the transmitted signals. Although higher-bandwidth efficiency can be obtained in blind techniques due to the lack of training overhead, the convergence speed and estimation accuracy are significantly compromised. Blind Channel Estimation has its advantage in that it has no overhead loss. It is only applicable to slowly time-varying channels due to its need for a long data record. Semi-blind channel technique is hybrid of blind and training technique, utilizing pilots and other natural constraints to perform channel estimation. For this reason, training-based channel-estimation techniques are more reliable, more prevalent, and supported by the WiMAX standard.

IV. PILOT BASED CHANNEL ESTIMATION

Pilot provides coherent data detection to decrease error. Receiver performs channel estimation based on received pilot symbols. It is used for synchronization, continuity. The pilots will be inserted to all subcarriers uniformly between the information data sequence which is shown in Fig 2. The training-based method channel estimation can be performed by either block type pilots where pilot tones are inserted into all frequency bins within periodic intervals of OFDM blocks or by comb pilots where pilot tones are inserted into each OFDM symbols with a specific period of frequency

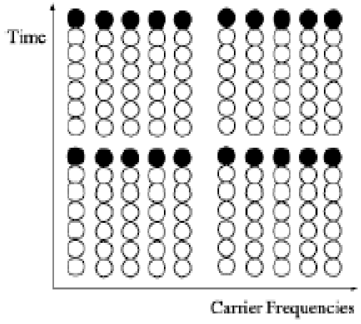

Fig 2. Block Type Pilot Channel Estimation

In training based channel estimation algorithms, training symbols or pilot tones that are known to the receiver are multiplexed along with the data stream for channel estimation. The idea behind these methods is to exploit knowledge of transmitted pilot symbols at the receiver to estimate the channel. For a block fading channel, where the channel is constant over a few OFDM symbols, the pilots are transmitted on all subcarriers in periodic intervals of OFDM blocks. This type of pilot arrangement, depicted in Figure 2 is called the block type arrangement.

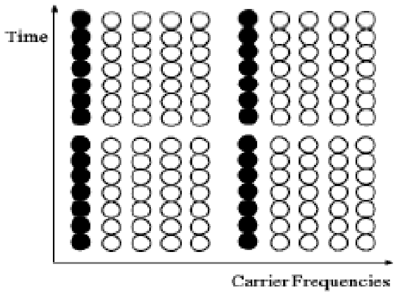

Fig 3. Comb Type Pilot Channel Estimation

V. TYPES OF CHANNEL MODEL AND ESTIMATION ALGORITHMS

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 three channel models namely, Additive White Gaussian Noise (AWGN), Rayleigh and Rician. It is done by implementing LS, MMSE and LS-Modified channel estimation algorithms.

ADDITIVE WHITE GAUSSIAN NOISE CHANNEL

Additive White Gaussian Noise (AWGN) is a channel model in which only impairment to communication is a linear addition of wideband or white noise with a constant spectral density and a Gaussian distribution of amplitude. This model does not account for fading, frequency selectivity, interference, non-linearity or dispersion. AWGN is common to every communication channels, which is statistically random radio noise characterized by a wide frequency range with regards to a signal in communication channel. The assumptions are noise is additive, white and noise samples have a Gaussian distribution.

1) Least Square Algorithm:

LS Minimize the sum of squared residuals

Residual = Observed value- fitted value

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 made in the results of every single equation.

$$H_{LS}= XY$$

Where X= Input

Y= Output

H_{LS}=Channel matrix for LS Algorithm

2) Minimum mean square Error Algorithm

MMSE estimator describes the approach which minimizes the Mean Square Error (MSE), which is a common means of estimator quality. MMSE channel model is estimated using the equation given below

$$MSE= E\{(H-H_{LS})^{h}(H-H_{ls}^{)}\}$$

Where H= Input Channel matrix

H_{LS}= Channel Matri for LS algorithm

MSE= Mean square Error

3) least Square Modified Algorithm

This approach finds the most important application in data fitting. The best fit in the least-squares sense minimizes the sum of squared residuals, a residual being the difference between an observed by a model

$$H_{EST}(i) =\{ H_{EST}(i)+H_{EST}(i+1)\}/2$$

Where $H_{est}(i)$= estimated channel matrix for i^{th} value

$H_{EST}(i+1)$= estimated channel matrix for $(i+1)^{th}$ value

H_{est} =Estimated channel matrix

From LS algorithm $H_{est}= H_{EST}H_{EST}(end)$

Advantages of Modified LS

- Reduce non linearity effect or Regression effect
- Reduce uncertainty problems
- Improve data fitting
- Decrease BER
- Improve performance

STEPS TO CALCULATE BER FOR CHANNEL

Step 1: Initialize the various parameters such as number of subcarriers, number of pilots, guard interval and SNR.

Step 2: Generate G matrix by using formula.

Step 3: Generate OFDM symbols for random input data and encode it by using trellis algorithm.

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, LS Modified, MMSE algorithms.

Step 8: Finally the received data is demodulated and decoded by using viterbi algorithm.

Step 9: Plot the graph for BER and end the process.

Network Parameters:

Number of sub carrier	16
FFT Size	64
Modulation type	16QAM
Channel model	AWGN
Number of pilots	8
Guard interval	16
Encoder	Trellis
Decoder	Viterbi

VI. RESULTS

AWGN Channel for N=16 and pilot channel = 8

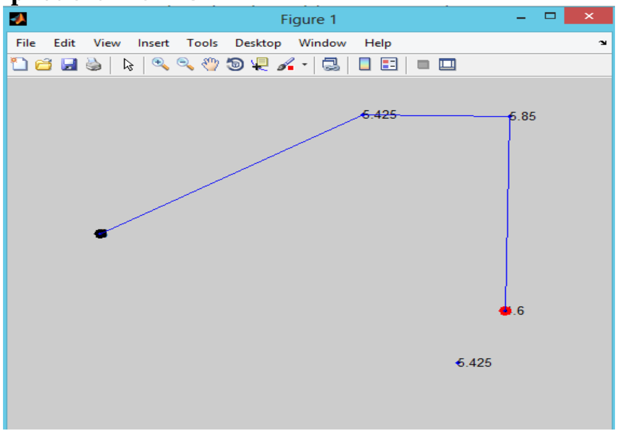

Figure 4 random positions of transmitter node and reciver node

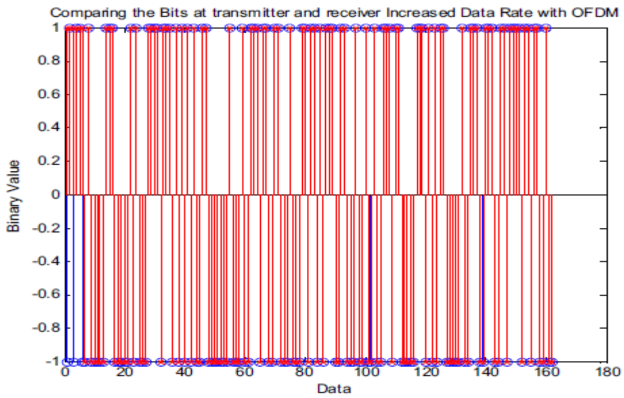

Fig5 Comparing no of bits transmitter and receiver

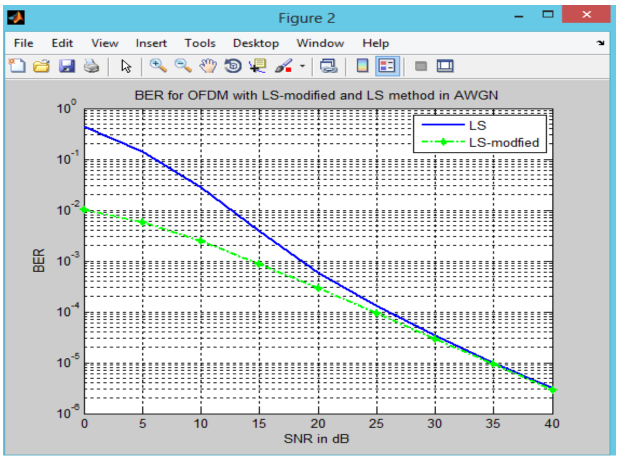

Fig 6 BER VRS SNR OF LS and Modified LS

Figure 6 represents the SNR vs BER graph for AWGN channel using LS and LS-Modified algorithms. From the graph it is inferred that LS-Modified algorithm has low BER value.

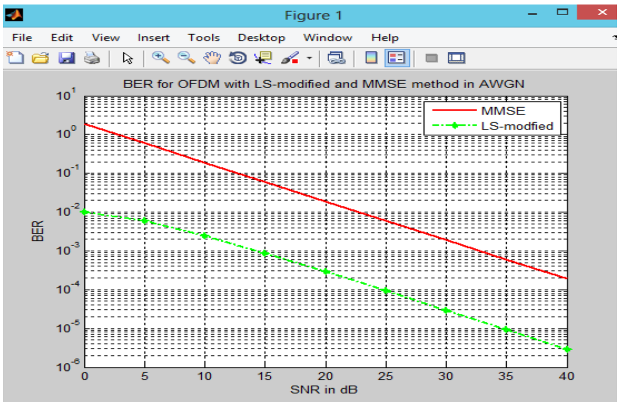

Fig. 7 BER VRS SNR MMSE and Modified LS

Figure 7 represents the SNR vs BER graph for AWGN channel using MMSE and LS-Modified algorithms. From the graph it is inferred that LS-Modified algorithm has low BER value.

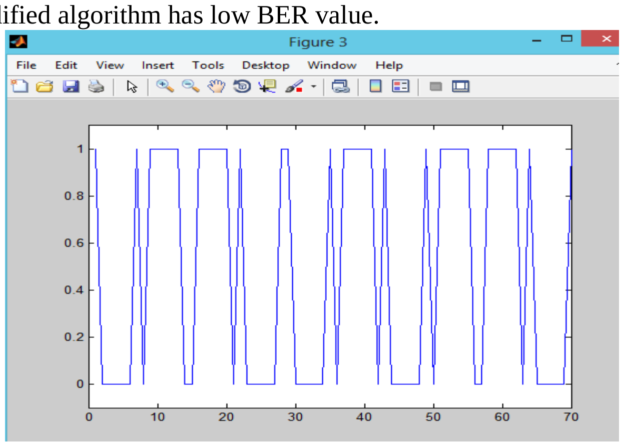

Fig. 8 channel matrix for pilot channel

Figure 8 represents the channel matrix plotted between Samples and Magnitude values for AWGN channel.

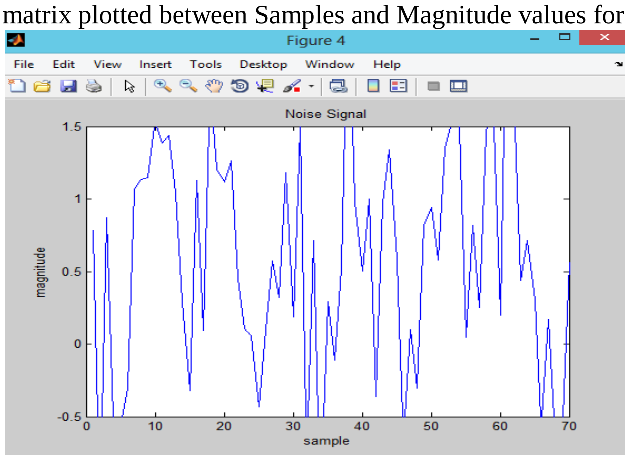

Fig. 9 Noise level

Figure 9 represents the noise level in AWGN channel during the transmission of the signal.

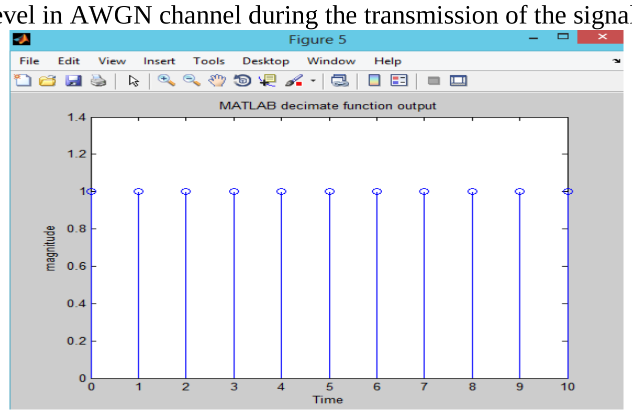

Fig 10 pilot positions

Figure 10 represents the position of pilot inserted for every 8 bits for synchronization

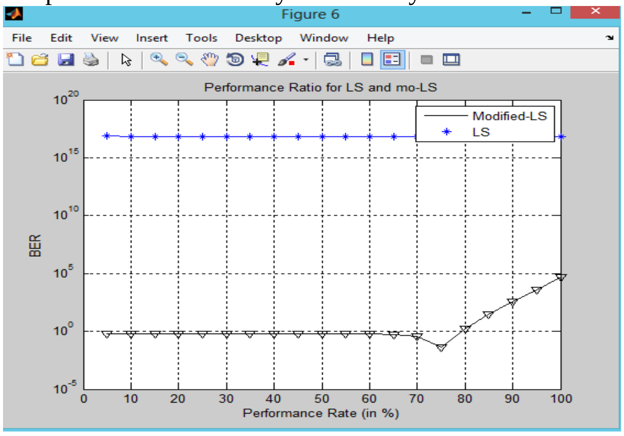

Fig 11 Performance comparison

VII. CONCLUSION

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 MIMOOFDM system is optimized with minimum bit error rate. OFDM with multiple transmit and receive antennas form a MIMO system to increase system capacity. Thus the AWGN channel BER estimated using three algorithms. From the graph it is inferred that in low SNR, MMSE is better than that of LS, its main problem is its high computational complexity, but LS_ Modified Algorithm is suitable. In our proposed system, we have estimated the AWGN channel models using LS,MMSE and LS_ Modified algorithms. This project can be further extended by estimating the three channels using RLS and NLMS algorithms and to compare their bit error rate performances.

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