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MIMO-OFDM System Using Bit Error Rate LS & MSE Analysis in Pilot Based Channel Estimation

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***Abstract*:** With the expanding data moving over the remote frameworks, the channel capacity is lessening on a fast rate. To empower high piece rate information move we need wide channel capacity. This can be actualized by utilizing Multiple Input-Multiple Output (MIMO) that is, executing various sending recieving wires and numerous accepting radio wires. Symmetrical Frequency Division Multiplexing (OFDM) when utilized with MIMO improves the nature of the sending data and limit of the communicating channel. In this examination, MIMO and OFDM are applied together so as to decrease Signal-to-Noise Ratio (SNR) and improve the blunders experienced. Here, different channel assessment methods are dissected and executed, for example, (LS) Least Squares and (MMSE) Minimum Mean Square Error for MIMO-OFDM System. The Bit Error Rate, Mean Square Error (MSE) execution attributes of channel are examined for Quadrature Amplitude Modulation (QAM) conspire over the Additive White Gaussian clamor (AWGN). The general presentation of the proposed strategy and existing procedure is estimated utilizing BER and MSE.

Keywords- MIMO (Multiple input multiple output), OFDM (Orthogonal frequency division multiplexing), SNR (signal to noise ratio), MSE (Mean square Error), QAM (quadrature amplitude modulation), AWGN (additive white Gaussian noise)

I. INTRODUCTION

The use of wireless networks is rapidly increasing like a fire in the forest. With this there is also increase in the demand of high transmission speed, better quality of transmission and decrease in rate of setting up of these wireless systems. Almost every type of businesses has become mobile. People like to work freely, without bound to sit in a place and do some work on the desktop computers. This tends to the research and finding of solutions to address these problems. Various techniques or methods were proposed in order to increase the speed, quality and decrease the cost of the wireless transmission systems [1].

The best considered technique till today is Multiple-Input Multiple-Output (MIMO) technique. This method utilizing multiple transmitter antennas and multiple receiving antennas have helped in increasing the data- rate. Multiple-Input Multiple-Output (MIMO) has significant advantages over the traditional technique known as Single-Input Single-Output (SISO) [2]. Single-Input Single-Output mainly involves the usage of single transmitting and receiving antennas leadings to low channel capacity. Whereas in MIMO, the high channel bandwidth allows more data to get transmitted. Multiple-Input Multiple-Output (MIMO) technique, with multiple transmitting and receiving antennas increases the system capacity.

Implementing merely MIMO technique can result in an increase in Inter Symbol Interference (ISI) [3] . A hybrid system of MIMO-OFDM helps in minimizing Inter Symbol Interference and also converts selective fading into flat fading.Another technique, Orthogonal Frequency Division Multiplexing (OFDM), has also helped in enhancing the quality of the transmitted and received data over the wireless communication systems.

(MIMO) Multiple Input Multiple Output has been used in realistic life and technology for (SISO) Single Input Single Output [4]. MIMO wireless antenna systems will be used in future in wireless communication. MIMO (multiple input, multiple output) techniques are used multiple transmitter and multiple receiver antennas that helps in the wireless communication channel without fading. Multiple Input Multiple Output has helps in spatial diversity and spatial multiplexing [8]. MIMO provides the different ranges in space. MIMO implemented using the spatial diversity techniques provide the diversity gain and improving the reliability.

In Orthogonal Frequency Division Multiplexing (OFDM) system single channel use multiple sub carriers of different frequency to differentiate the frequency division multiplexing [5]. To enhance the capacity or spectral efficiency of the overlapping we use sub carriers in OFDM (Orthogonal Frequency Division Multiplexing) system [9]. Usually the interfacing in the signals or the channel is called overlapping [6]. All the sub-carriers in an Orthogonal Frequency Division Multiplexing system are completely orthogonal to each other. By this factor they can be easily able to overlapping without interfering [8]. Due to the OFDM systems are increasing the spectral efficiency without causing bordering channel interference.Orthogonal Frequency Division Multiplexing system has been explained in the various sections. It consists of the transmitter part and the receiving part.

In the block diagram of OFDM system the transmitter, is a convolution encoder first encodes the binary input data. Encoder just encodes the signals of change carriers in the form of binary data. After getting the output, binary values are substituted on M-PSK (Phase Shift Key) or M-QAM (Quadrature Amplitude Modulation) modulator. These binary values are read by M-PSK and M-QAM. In the next block of Serial to Parallel block, the serial input symbol-stream is renewed to a parallel stream with width equal to the number of sub carriers.

II. SYSTEM MODEL

The MIMO algorithms are narrowband algorithms.In order to deal with the frequency selective nature of wideband wireless channels, MIMO can be join with OFDM. Effectively, OFDM transforms a frequency-selective channel into parallel flat-fading sub channels, i.e., the signals on the subcarriers undergo narrowband fading. In this way, MIMO and OFDM are complementing each other. Hence, by performing MIMO transmission and detection per subcarrier, MIMO algorithms can be functional in broadband communication [12].

In Multiple Input Multiple Output-Orthogonal Frequency Division Multiplexing transceiver block diagram system with Nt transmitter (TX) and Nr receiver (RX) antennas shown in Fig.3. In spite of spatial and temporal dimension of Multiple Input Multiple Output, Orthogonal Frequency Division Multiplexing provide extra dimension to exploit, namely, the frequency dimension multiplexing. In block diagram, generally the incoming bit stream is first encoded by a one-dimensional encoder after which the encoded bits are mapped onto the three offered dimensions by the Space-Time-Frequency (STF) mapped [10]. After this every signal Space Time Frequency map per, each TX branch consists of almost an entire Orthogonal Frequency Division Multiplexing transmitter.

At the receiver side, remove the CP and the Fast Fourier Transform is proceed in receiver branch. Unique Space Time Frequency is obtained in the form of course and they are decoded to obtain the binary data stream.

In general, however, because the Multiple Input Multiple Output algorithms are single carrier algorithms, Multiple Input Multiple Output detection is achieved per Orthogonal Frequency Division Multiplexing subcarrier. To that end, the received signals of the i-th subcarrier are detected by the Multiple Input Multiple Output detector and improve the Nt QAM (Quadrature Amplitude Modulation) symbols transmitted on that subcarrier. MIMO algorithm is single carrier algorithm. Next, the symbols per transmission TX stream are combined and Space Time Frequency de-mapping and decoding are performed on these Nt parallel streams and the resultant data are combined to attain the binary output data or the symbol then obtain are combine with space time frequency and decoded on parallel stream and data can be obtained in receiver is binary output data. [13], [14], [15].

Thus the conclusion, OFDM provides so many advantages in parallelism stream by means of its Nc subcarriers. The information thus obtained is done by Multiple Input Multiple Output-Orthogonal Frequency Division Multiplexing. If MIMO detection is performed per subcarrier, then a given detector is allowed to work Nc times slower than the Multiple Input Multiple Output detector of an equivalent single carrier system with comparable data rate. Although in the case of Multiple Input Multiple Output, Orthogonal Frequency Division Multiplexing, Nc of such detectors is required, they can work in parallel, which might ease the implementation. [16].In case Multiple Input Multiple Output we requires Nc detector that can parallel and they can be easily used.

III. CHANNEL ESTIMATION

Physical medium in which the charge carriers move is affected by the channel estimation. Channel estimation is an essential function for wireless systems. Without channel estimation the wireless system is not possible. In wireless channel properties, a receiver can achieve insight into the data sent over by the transmitter antennas. The major ambition of Channel Estimation is to know the channel and its property of the channel or partially known set of transmissions.

Orthogonal frequency division multiplexing (OFDM) systems are subcarrier to transmit data. These are closely packed system. This package helps in high speed data rate that is able to estimate the minimum delay in subcarrier and output data.

Channel estimation is explained by the Pilot based Channel Estimation Techniques. Pilot based technique helps in estimation of output. The output that we receive at receiver can be estimated by the Pilot techniques. In Pilot based estimation, the Channel Impulse Response (CIR) is estimated with bits sent by the receiver. At the receiver end with the help of training bits can generate its own response. Subcarriers are in the form of bits at receiver channel. Training sequence is base of channel estimation at both ends such as transmitter and receiver.
For an Nt number of transmitter antenna and Nr is number of receive antennas in system, the complexity of any kind of signal processing algorithms at the physical layer is increased usually by a factor of NtNr. Hence, simplicity plays an important role in the system design. We propose a pilot tone design for Multiple Input Multiple Output-Orthogonal Frequency Division Multiplexing channel

estimation that Nt number of transmission isdislocate set of pilot tones are placed on one OFDM block at each transmit antenna. For each pilot tone set, it has *L* (L: channel length) pilot tones which are equally-spaced and equally- powered. The pilot tones from different transmit antennas contain a unitary matrix and then a simple least square estimation of the MIMO channel is easily implemented by taking benefit of the unitarily of the pilot tone matrix. There is no need to compute the inverse of large-size matrix which is typically required by LS (least square) algorithm. Contrast to some other simplified channel estimation methods by assuming that there are only a few dominant paths among Lof them and then neglecting the rest weaker paths in the channel, Pilot methods estimates the full channel information with a reduced complexity.

IV. PROBLEM FORMULATION

MIMO (Multiple Input-Multiple Output): In layman's language MIMO is important for 4G & 5G wireless communication. In this technique we used multiple antennas that increase the capacity of transmitted signals. We use multiple transmitted and received antennas to explicitly multipath propagation. Without Multiple Input-Multiple Output wireless communication is quit impossible. During few years we used Multiple Input-Multiple Output system in Power line communication.

Initially we just use. MIMO in wireless as multiple antennas at the Receiver & Transmitter end but in modern time we used Multiple Input-Multiple Output in practical Technique for Transmitting & Receiving the single of more than one data at same time & at same Radio channel by exploiting the multipath propagation.We cannot compare smart antennas techniques with MIMO as they both are different but Multiple Input-Multiple Output increases the performance single data signal like being forming & diversity.

OFDM (Orthogonal Frequency Division Multiplexing): Wi-Fi antenna use Orthogonal Frequency Division Multiplexing for wireless and telecommunication. It is also used in cellular Telecommunication standards and Wi-Max etc. With the help of Orthogonal Frequency Division Multiplexing number of broadcast standards for digital radio Digital Audio Video can be converted to digital video broadcast standard.In Orthogonal Frequency Division Multiplexing long medium and short medium wave bands are used. Initially OFDM is quit complicated during its earlier form and not easy to understand. In spite of this Orthogonal Frequency Division Multiplexing as some advantages in terms of data transmission. Orthogonal Frequency Division Multiplexing is advanced and effective method for digital multicarrier modulation.

BER(Bit Error Rate):In digital transmission due to noise interference number of bit errors are produced in communication channels. BER always expressed in percentage due to unit less quantity. At the probability is always expected value for BER. The expected value of is always accurate for long time intervals.

LSE (Least Square Error): LSE is systematic method for the analysis to give the solution of over determine system. LS are the overall solution that minimizes the sum of square of residual in resultant in all the equation. Its most unique application is in data feting. Least Square is used to minimize sum of square residuals. For a problem is substantial as a certainty in independent variable we used error in variable modals. Instead of least square. It is divided in two parts first one is Ordinary Least Square and second is Non-Linear least square. It depends upon the linear in all unknowns.

In statistics closed form solution is used. Iterative methods are generally used that helps in core calculation of linear solution. Polynomial least describes the variance dependent and independent variables. Least square can be also used for exponential family.This pilot based channel estimator is designed for a MIMO-OFDM [11]. We can express the Least squares estimation of the channel as follows [9]:

$$\hat{H_{LS}} = \arg\{\min\{(Y-X\hat{H_{LS}})H(Y-X\hat{H_{LS}})\}\} \quad (1)$$

Where $\widehat{H}_{LS}$ is the channel estimation for LS method.

Hence,

$$\hat{H_{LS}} = \frac{Y}{X} = H + \frac{N}{X} \quad (2)$$

Here AWGN is the additive Gaussian noise and $\widehat{H}_{LS}$ is the channel estimation of the system. Y is the received data and X is the transmitted symbols. Matrix X has transmitted symbol in each of the N subcarriers in its diagonal. Here H is channel frequency response Adaptive filter is also used in LMS estimator at each pilot frequency. With LS one thing is good that it can give the first value directly and the rest values are computed based on the previous estimation and the current channel output, in this technique the word d (n) is the desired response of the adaptive filter, and word e(n) is error signal[5].

MSE (Mean Square Error): MSE measure the average of square of error in statistics. It's a risk function corresponding to expected value. It can never be zero because of its randomness. It is used in measuring the quality of estimator and always in non-negative. MSE is a second moment about the origins of error and include variance of estimator. MSE is an unbiased estimator, invariance of estimator.

Least Squares Error (LSE) estimation technique can be used to estimate the system by minimizing the squared error between estimation and detection [12]. The least-square (LS) channel estimation method finds the channel estimate $\widehat{H}$ in such a way that the following cost function is minimized:

$$J(\hat{H}) = \left\|Y - X\hat{H}\right\|^2 \quad (3)$$

$$= (Y - X\hat{H})^H (Y - X\hat{H})$$
$$= Y^H Y - Y^H X\hat{H} - X^H Y + X^H X\hat{H}^H \hat{H}$$

By setting the derivative of the function with respect to $\hat{H}$ to zero.

$$\frac{\partial J(\hat{H})}{\partial \hat{H}} = -2(X^H Y) * +2(X^H X\hat{H}) = 0 \quad (4)$$

We have $X^H X\hat{H} = X^H Y$, which gives the solution to the LS channel estimation as

$$\hat{H}_{LS} = (X^H X)^{-1} X^H Y = X^{-1} Y \quad (5)$$

The LS channel estimate $\hat{H}_{LS}$ can be written for each subcarrier as

$$\hat{H}_{LS}[K] = \frac{Y(K)}{X(K)}, K = 0, 1, 2, \ldots\ldots\ldots.., N-1 \quad (6)$$

The Mean-Square error (MSE) of this LS channel estimate is given as

$$MSE_{LS} = E\left\{(H - \hat{H}_{LS})^H (H - \hat{H}_{LS})\right\}$$
$$= E\{(H - X^{-1}Y)^H (H - X^{-1}Y)\}$$
$$= E\{(X^{-1}Z)^H (X^{-1}Z)\}$$
$$= E\{Z^H (X X^H)^{-1} Z\}$$
$$= \frac{\sigma_Z^2}{\sigma_x^2} \quad (7)$$

Minimum Mean Square Error (MMSE) Channel Estimation: Consider the LS solution in Equation (3), $\hat{H}_{LS} = X^{-1}Y = \tilde{H}$. Using the weight matrix W, define $\hat{H} = W\tilde{H}$, which corresponds to the MMSE estimate. MSE of the channel estimate $\hat{H}$ is given as

$$J(\hat{H}) = E\left\{\left\|e\right\|^2\right\} = E\left\{\left\|H - \hat{H}\right\|^2\right\} \quad (8)$$

Then, the MMSE channel estimation method [19], [20] finds a better (linear) estimate in terms of W in such a way that the MSE in Equation (8) is minimized.

The orthogonality principle states that the estimation error vector $e = H - \hat{H}$ is orthogonal to $\tilde{H}$, such that

$$E\{e\tilde{H}^H\} = E\{(H - \hat{H})\tilde{H}^H\}$$
$$= E\{(H - W\tilde{H})\tilde{H}^H\} = E\{H\tilde{H}^H\} - WE\{\tilde{H}\tilde{H}^H\}$$
$$= R_{H\tilde{H}} - WR_{\tilde{H}\tilde{H}} = 0 \quad (9)$$

Solving the equation for W yields

$$W = R_{H\tilde{H}} - R_{\tilde{H}\tilde{H}}^{-1} \quad (10)$$

Where $R_{\tilde{H}\tilde{H}}$ is the auto correlation matrix of $\tilde{H}$ given as

$$R_{H\tilde{H}} = E\{\tilde{H}\tilde{H}^H\}$$

Where $\tilde{H} = X^{-1}Y = H + X^{-1}Z$, therefore

$$= E\{X^{-1}Y(X^{-1}Y)^H\}$$
$$= E\{(H + X^{-1}Z)(H + X^{-1} + Z)^H\}$$
$$= E\{HH^H\} + E\{X^{-1}ZZ^H(X^{-1})^H\}$$
$$= E\{HH^H\} + \frac{\sigma_Z^2}{\sigma_X^2} I \quad (11)$$

And $R_{H\tilde{H}}$ is the cross-correlation matrix between the true channel vector and temporary channel estimate vector in the frequency domain. The MMSE channel estimate follows as

$$\hat{H} = W\tilde{H} = R_{H\tilde{H}} - R_{\tilde{H}\tilde{H}}^{-1}\tilde{H}$$
$$= R_{H\tilde{H}}\left(R_{HH} + \frac{\sigma_Z^2}{\sigma_X^2} I\right)\tilde{H} \quad (12)$$

Linear Minimum Least Square Estimator (LS-MME): The LS-MSE channel estimator [1] tries to minimize the mean square error between the actual and estimated channels, obtained by applying the Wiener–Hof equation:

$$h_{lmmse} = R_{hy} R_{yy}^{-1} y \quad (13)$$

Where the cross correlation matrix is:

$$R_{hy} = E[hy^H] = R_{hh} X^H \quad (14)$$

The autocorrelation of received signal y is:

$$R_{yy} = E[yy^H] = XR_{hh}X^H + \sigma_n^2 I \quad (15)$$

The LMMSE estimator can be found as:

$$h_{lmmse} = R_{hh}[R_{hh} + \sigma_n^2 (XX^H)^{-1}]^{-1} h_{ls} \quad (16)$$

V. RESULTS AND DISCUSSIONS

In this simulation, the Bit Error Rate, Mean Square Error performance in channel with 4QAM modulation schemes are verified with different estimation techniques in Adaptive White Gaussian Noise (AWGN) and Rayleigh fading channel using Matlab software are shown in Fig. 1 and 2.All elements of channel matrix H are assumed to be zero i.e. zero mean complex Gaussian random variables with unit variance. The input SNR is described as the ratio of the anticipated received strength at each antenna to the noise power. The channel estimation errors are randomly generated from a Gaussian distribution. The overall performance of the proposed approach and present technique is measured the using BER and number of errors. A plot of BER vs. SNR is given in figure 1. It's far nearly clear from the graphs that proposed technique has an awful lot decrease BER compared to that of existing LSE and existing MMSE. This is because traditional LSE algorithm most effective considers the noise power and ignores the interference whilst producing the null weight. The effect of channel estimation error turns into more dominant as the SNR increases.The BER performance for the same is given in figure 2.

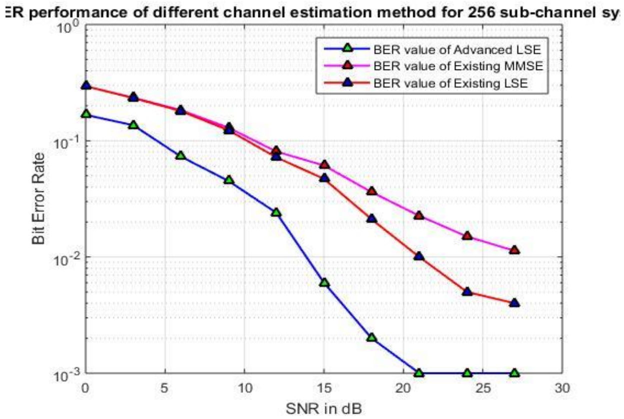

Fig.1. BER V/s SNR for Advanced LSE

In 4-QAM, Mean Square Error performance with LS and MMSE are shown in Fig.2 Here also LS decreases sharply with increase of SNR but MMSE decreases slightly with increase of SNR in both AWGN channel & Rayleigh fading channel.

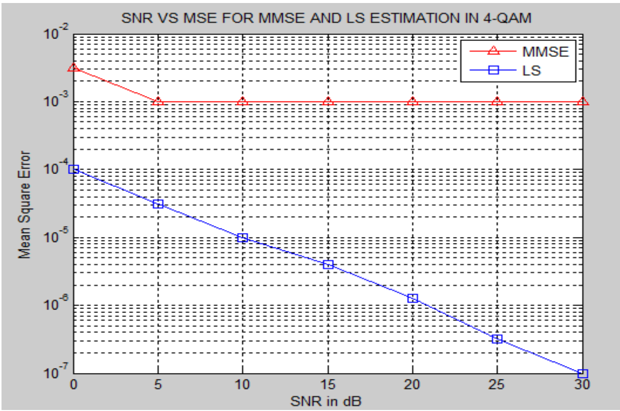

Fig.2. SNR V/s MSE for MMSE and LS in 4-QAM

In 8-QAM, Mean Square Error performance with LS and MMSE are shown in Fig.3 Here LS and MMSE decreases parallel with increase of SNR. The performance of 8-QAM is efficient than 4-QAM because of increase of modulation order mean square error performance also increases.

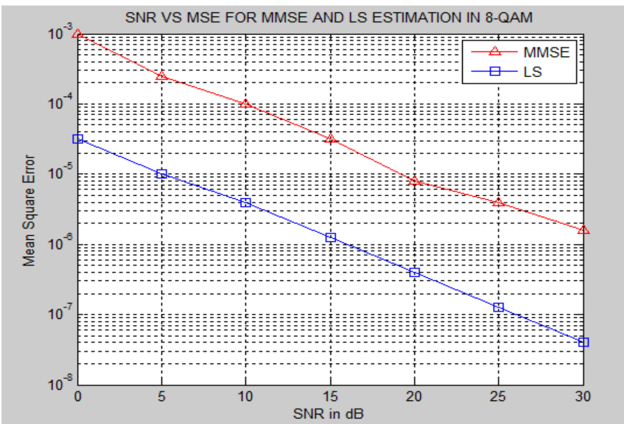

Fig.3. SNR V/s MSE for MMSE and LS in 8-QAM

For different modulation with *N* branch diversity, assuming channel information is known and fading channel the performance analysis is made in this work. The noise added by the channel is also presumed to be Gaussian random noise. The goal of our analysis is to highlight the performance of this system by comparing them with various interconnected systems. For analysis of the effectiveness of this system a performance measure is made between the Es No (in dB) and Channel MSE. The system shown in Fig.2 consists of a MIMO-OFDM implementation with channel estimators. It shows the diverge performance for the various channels.

VI. CONCLUSION

The bottleneck problem of complexity for channelestimation in MIMO-OFDM systems has been studied by two different approaches. The first one shortens the sequence of training symbols to the length of the MIMO channel, leading to orthogonal structure for preamble design. Its drawback lies in the increase of the overhead due to the extra training OFDM blocks. The second one is the simplified channel estimation algorithm that achieves optimum channel estimation and also avoids the matrix inversion. Our contribution in this paper is the unification of the known results of in that the simplified channel estimation algorithm is generalized to explicit orthogonal space-frequency codes (SFC) that inherit the same computational advantage as inwhile eliminating their respective drawbacks. In addition, thedrastic performance degradation occurred in is avoided byour pilot-tone design since the channel is estimated at each block. In fact we have formulated the channel estimation problem in frequency domain, and the CFR is parameterized by the pilot-tones in a convenient form for design of SFC. As a result a unitary matrix, composed of pilot-tones from each transmit antenna, can be readily constructed. It is interesting to observe that the LS algorithm based on SFC in this paper is parallel to that for conventional OFDM systems with single transmit/receive antenna. The use of multiple transmit/receive antennas offers more design freedom that provides further improvements on estimation performance.

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