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Pilot Based MMSE algorithm to evaluated MSE & SER along with SNR

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ABSTRACT: In this paper ,main focus is on modern wireless broadband communication system like Multiple Input Multiple output(MIMO) combined with Orthogonal Frequency Division Multiplexing(OFDM).It can accomplish unfailing high data rate and better spectral efficiency. It is more popular because of its good quality data transmission rate and its sturdiness against multipath fading. This communication system provides unfailing communication & wide coverage. The main challenge to MIMO-OFDM system is to rescue of the Channel State Information (CSI) perfectly and coordinated between transmitter & receiver. Channel estimation technique based on pilot arrangement for Multiple Input Multiple Output (MIMO) for Rayleigh fading channel is proposed in this paper. The channel estimation using block type pilot arrangement is carried out with Minimum mean square (MMSE) estimation algorithms through mat lab simulation. The performance of channel estimation techniques MMSE is evaluated parameter like Mean Square Error (MSE) & Symbol Error Rate (SER) along with the Signal to Noise Ratio (SNR).

KEYWORDS: MIMO-OFDM, Channel State Information, MMSE Estimation, Mean Square Error, pilot carrier.

I.INTRODUCTION

The performance of wireless communication system is mainly governed by wireless environment [1]. The wireless channel is dynamic and impulsive, which makes an precise analysis of the wireless communication system habitually complicated .The emerging scheme in modern wireless communication system is the use of multiple antennas in both transmitter and receiver sides which potentially provides high data-rate communications with bandwidth efficiency. The multipath fading channels causes inter symbol interference (ISI) in the received signal [1]. The detection algorithms should have the understanding of channel impulse response to remove ISI from the signal at the receiver. The channel estimation is based on the known repetitive sequence of bits in every transmission rupture and the consequent received samples. Orthogonal frequency division multiplexing (OFDM) isa multi-carrier modulation and multiplexing technique which is used to transmit high data rate in the course of wireless channels. The transmitter modulates the signal sequence into PSK/QAM symbols, performs IFFT on the symbols and cyclic prefix is added. So that Inter symbol interference (ISI) and inter carrier interference (ICI) are eliminated. Spectral efficiency can be achieved in OFDM by using orthogonal subcarriers. The different type's algorithms to estimate channel state information are training based, blind and semi blind channel estimation. Blind channel estimation uses the statistical properties of received signals, the channel can be estimated without resorting to the preamble or pilot signals [6]. A blind channel estimation technique has an benefit of not incurring an transparency with training signals. However, it often desires a large number of received symbols to take out statistical properties. Both Transmitter and receiver know the training based channel estimation training symbols. The semi blind channel estimation is a mixture of blind channel estimation and training based channel estimation. The training based channel estimation is performed by block type pilot arrangement. In block type pilot arrangement, OFDM symbols with pilots at all subcarriers are transmitted occasionally for channel estimation. Since pilot tones are inserted keen on all subcarriers of pilot symbols with a period in time, the block type pilot arrangement is appropriate for slow fading channels. The channel estimations techniques MMSE are implemented. Space time block coding is used to transmit data crosswise number of antennas at transmitter and receiver to get better reliability of data transfer.

In a wireless link, channel state information (CSI) provides the known channel properties of the link. It provides the aspect of signal propagation between transmitter and the receiver and tells about the effects of scattering, fading. The

CSI can integrate current channel conditions with transmission data for achieving consistent communication. This CSI should be estimated at the receiver and fed back to the transmitter. The channel state information can be achieved through different types of channel estimation algorithms .This estimation can be done with a set of well-known sequence of unique bits for a particular transmitter and the same can be continual in every transmission burst. Thus the channel estimator estimates the channel impulse response for each burst separately from the well-known transmitted bits and corresponding received samples.

II.LITERATURE SURVEY

G.Lohit0ha, M [1] et.al discuss about efficient modified Newton method (MNM) for minimizing the established cost function. This paper proposes a space-time semi-blind equalizer (ST-SBE) for dispersive multiple-input multiple-output (MIMO) communication systems that employ high throughput quadrature amplitude modulation (QAM) signals. A novel cost function (CF) that integrates multi modulus algorithm (MMA) with soft decision-directed (SDD) scheme is established to efficiently obtain the weight vector associated with the ST-SBE. In the ST-SBE, a very short training sequence is used to provide a rough initial least squares estimate of the weight vector. An efficient modified Newton method (MNM) for minimizing the established cost function is proposed to fast search the optimal weight vector. Very interestingly, we prove that the proposed MNM has the same quadratic order of convergence as Newton methods. In addition, the proposed MNM has much lower computational complexity than Newton methods. Simulation results are provided to demonstrate that the ST-SBE has better performances than the gradient-Newton (GN)-based concurrent constant modulus algorithm (CMA) with SDD scheme (GNCMA+SDD).

R.S.Ganesh [2] at.al discusses about different channel estimation algorithms. A Modern wireless broadband system of MIMO-OFDM (multiple input multiple output- orthogonal frequency division multiplexing) is more popular because of good data transmission rate and its robustness against multipath fading & good spectral efficiency. This system provides reliable communication & wide coverage. A main challenge to MIMO-OFDM system is retrieval of the channel state information (CSI) accurately and synchronization between the transmitter & receiver. The channel state information is retrieved with the help of various f estimation algorithms such as training based, blind and semi blind channel Estimation. This paper describes the basic introduction of OFDM, MIMO-OFDM system and explains the different channel estimation algorithms, optimization techniques and their utilization in MIMO system for 4G wireless mobile communication systems.

III. MIMO-OFDM SYSTEM

The block diagram of MIMO-OFDM is shown in figure1. MIMO-OFDM system among two transmitting and two receiving antennas is measured for easy analysis. In MIMO-OFDM system the transmitter modulates the message bit sequence in to QAM symbols and performs space-time coding, pilot insertion, IFFT and cyclic prefix is added for Nt parallel transmission paths and sends them through wireless channel. The received signal is habitually distorted by the channel characteristics. In categorize to get better the transmitted bits, the channel effect must be estimated in the receiver.

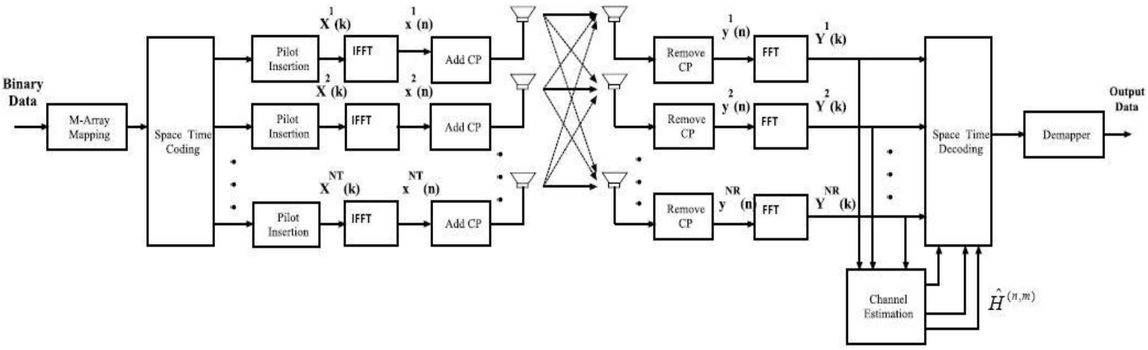

Figure1 .MIMO-OFDM System Modelling

The orthogonality allows each subcarrier component of the received signal to be articulate as the product of the transmitted signal and channel frequency response at the subcarrier. Thus, the transmitted signal can be improved by

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estimating the channel response just at every subcarrier. At the receiver cyclic prefix is detached and FFT is performed for each parallel path and then channel estimation and demodulation are performed. MIMO system employs multiple antennas in the transmitter and receiver [1]. The Nt signals are transmitted over Nt × Nr transmission paths concurrently. Nr received signals are mixture of Nt transmitted signals and noise. Channel estimation is difficult due to more channel coefficients. After message bit sequence undergoes modulation, the encoding matrix is given as

$$x = \begin{bmatrix} x_1 & -x_2^* \\ x_2 & x_1^* \end{bmatrix} \quad (1)$$

Where,

X1=(X[0]-X*[1]X[2]-X*[3]…-X*[N-1]) (2)
X2=(X[1] X*[0]X[3]-X*[2]…-X*[N-2]) (3)

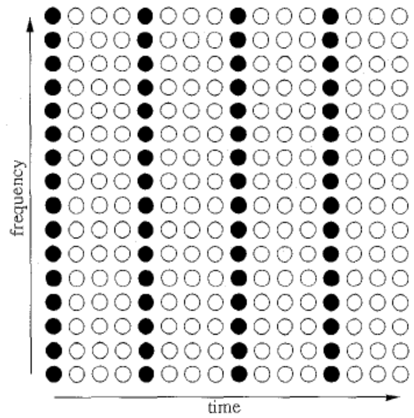
The vectors X1 and X2 are modulated using IFFT and then cyclic prefix is added. Cyclic prefix acts as guard time interval. Two modulated signals are transmitted by transmitter. The incoming signals are received by receiving antennas which is the convolution of channel and transmitted signal. At the receiver cyclic prefix is removed and performs FFT. The demodulated signal is represented by the equation (4)

$$\begin{bmatrix} Y_1 \\ \vdots \\ Y_{NR} \end{bmatrix} = \begin{bmatrix} H_{1,1} & \cdots & H_{1,NT} \\ \vdots & \ddots & \vdots \\ H_{NR,1} & \cdots & H_{NR,} \end{bmatrix} \begin{bmatrix} X_1 \\ \vdots \\ X_{NT} \end{bmatrix} + \begin{bmatrix} Z_1 \\ \vdots \\ Z_{NT} \end{bmatrix} \quad (4)$$

In the above equation $[Z1 \cdots ZNT]$ denotes additive white Gaussian noise. Hm, n is the channel gain between mth receiver and nth transmitter.

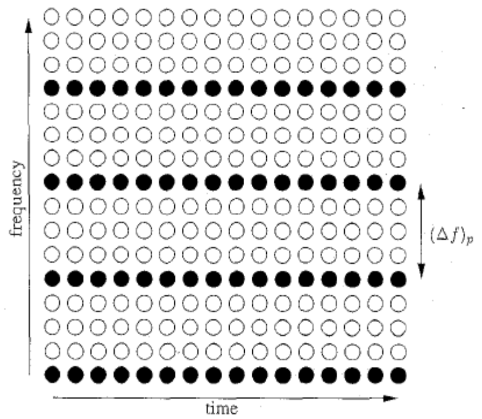
IV.MIMO-OFDM CHANNEL ESTIMATION

Based on the assumptions such as perfect synchronization and block fading, we end up with a compact and simple signal model for both the single antenna OFDM and MIMO-OFDM systems [5]. In training based channel estimation algorithms, the receiver knows the training symbols or pilot tones are multiplexed along with the data stream for channel estimation. The idea behind these methods is to make the most of knowledge of transmitted pilot symbols 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 Fig. 2(a), is called the block type arrangement. For a fast fading channel, where the channel changes between adjacent OFDM symbols, the pilots are transmitted at all times but with an even spacing on the subcarriers, representing a comb type pilot placement, Fig. 2(b) The channel estimates from the pilot subcarriers are interpolated to estimate the channel at the data subcarriers.



(a) Block-type pilot sub-carrier arrangement

Figure2a. Block-Type Pilot



(b) Comb-type pilot sub-carrier arrangement

Figure 2b.Comb-Type Pilot

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V. MMSE CHANNEL ESTIMATION

In statistics and signal processing, a minimum mean square error (MMSE) estimator is an estimation method which minimizes the mean square error (MSE) of the fitted values of a dependent variable, which is a common measure of estimator quality.

The term MMSE more specifically refers to estimation in a Bayesian setting with quadratic cost function. The basic idea behind the Bayesian approach to estimation stems from practical situations where we often have some prior information about the parameter to be estimated. For instance, we may have prior information about the range that the parameter can assume; or we may have an old estimate of the parameter that we want to modify when a new observation is made available. This is in contrast to the non-Bayesian approach like minimum-variance unbiased estimator (MVUE) where absolutely nothing is assumed to be known about the parameter in advance and which does not account for such situations. In the Bayesian approach, such prior information is captured by the prior probability density function of the parameters; and based directly on Bayes theorem, it allows us to make better posterior estimates as more observations become available. Thus unlike non-Bayesian approach where parameters of interest are assumed to be deterministic, but unknown constants, the Bayesian estimator seeks to estimate a parameter that is itself a random variable. Furthermore, Bayesian estimation can also deal with situations where the sequences of observations are not necessarily independent.

The minimum mean-square error (MMSE) estimate has been seen to be better than the LS estimate for channel estimation in OFDM systems based on block-type pilot arrangement. Regarding the mean square error of the estimation shown, the MMSE estimate has about 10-15 dB gain in SNR over the LS estimate for the same MSE values. The major drawback of the MMSE estimate is its high complexity, which grows exponentially with the observation samples. The mathematical representation for MMSE estimator of pilot signals is as follows,
The mean square error (MMSE) value between $yn(k)$ and $sn(k - kn)$is defined as:

$$J_{MSE}\ (W_n) = \mathrm{E}[|y_n(k) - s_n\ (k - k_n)|^2] \qquad (5)$$

Replacing ensemble average with time average, the CF is described by

$$\begin{aligned} J_{MSE}\ (W_n) &= \mathrm{E}[|y_n(k) - s_n\ (k - k_n)|^2] \\ &= \frac{1}{K-\tilde{K}} \textstyle\sum_{k=\tilde{K}+1}^{K} |y_n(k) - s_n(k - k_n)|^2 \\ &= \frac{1}{K-\tilde{K}} \textstyle\sum_{k=\tilde{K}+1}^{K} |W_n^H X(k) - s_n(k - k_n)|^2 \\ &= \frac{1}{K-\tilde{K}}\ (W_n^H \mathrm{X} X^H W_n - W_n^H X s_n^*(k_n)) \\ &\quad - \frac{1}{K-\tilde{K}} (s_n^T(k_n) X^H W_n - s_n^H(k_n) s_n(k_n)). \end{aligned} \qquad (6)$$

Where,**s**$n(kn)$ is the (K-$\dot{K}$)X 1 column vector given by

$$s_n\ (k_n) = [s_n(\tilde{K} + 1 - k_n), s_n(\tilde{K} + 2 - k_n), \ldots.. s_n(K - k_n)] \qquad (7)$$

Differentiating (7) with respect to **w**$n$and letting the gradient be 0, then the optimal MMSE solution is given by

$$W_{n;MMSE} = (XX^H)^{-1} \mathrm{X} s_n^*(k_n)$$

$$H = \begin{bmatrix} h_{11}(0)\ h_{12}(0) \cdots h_{1N}(0)\ h_{11}(1) \cdots h_{1N}(1)\ h_{11}(L-1) \cdots h_{1N}(L-1) \\ \vdots \quad \vdots \quad \vdots \quad \vdots \quad \vdots \quad \vdots \quad \vdots \quad \vdots \quad \vdots \quad \vdots \\ h_{M1}(0) h_{M2}(0) \cdots h_{MN}(0) h_{M1}(1) \cdots h_{MN}(1) h_{M1}(L-1) \cdots h_{MN}(L-1) \end{bmatrix} \epsilon C^{MXNL}$$

Note that there is a matrix inverse involved in the MMSE estimator, which must be calculated every time. This problem can be solved by using static pilots such as X_P (m) = c for m = 0, 1…, N_P - 1. A more generic solution is to average over the transmitted data, and a simplified Linear MMSE estimator of pilot signals is obtained.

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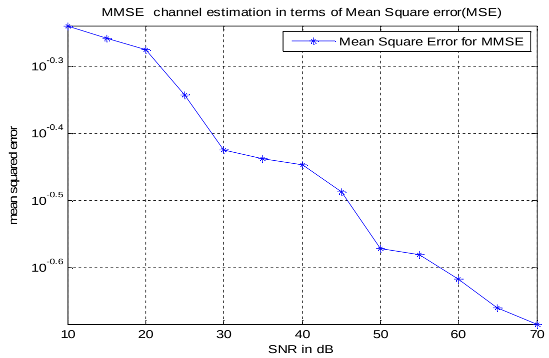
VI. SIMULATION RESULTS AND DISCUSSION

This MMSE Algorithm performs for different QAM modulation:

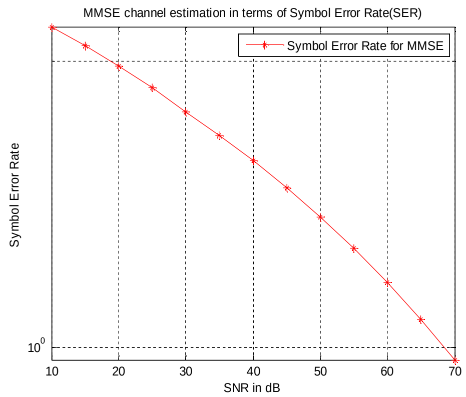
VI.I 4-QAM Modulation

i) The power factor is expressed in terms of Symbol to Noise Ratio (SNR) on X-axis and Mean Square Error (MSE) on Y-axis.



As the power level increases the Noise level decreases with decreasing Mean Square Error.

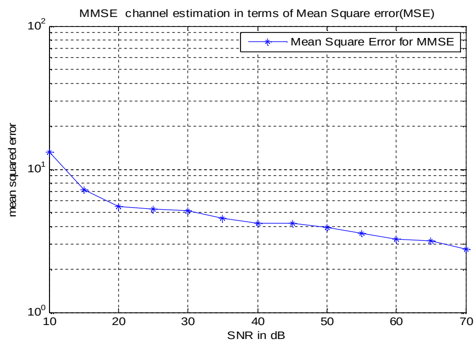
ii) The power factor is expressed in terms of Symbol to Noise Ratio (SNR) on X-axis and Symbol Error Rate (SER) on Y-axis.



For lower order QAM i.e. 4-QAM Symbol Error Rate is High. This means that the recovery of transmitted data is poor as compare to higher order QAM Modulation scheme.

VI.II 16-QAM Modulation

i) The power factor is expressed in terms of Symbol to Noise Ratio (SNR) on X-axis and Mean Square Error (MSE) on Y-axis



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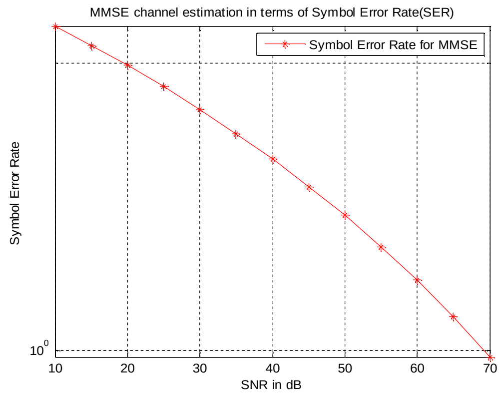
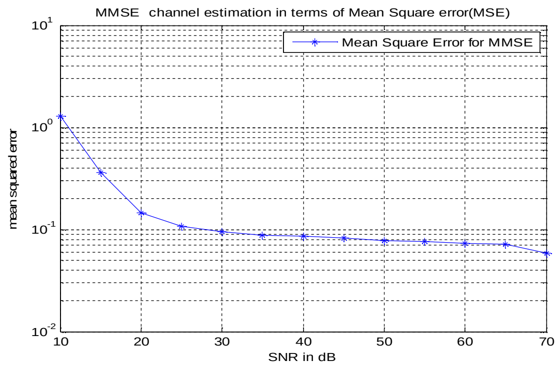
As compare to the 4-QAM the result are better i.e., the value of SER is less. At the same time, the no of iteration goes on increasing. But this number of iterations are less than 64-QAM.

ii) The power factor is expressed in terms of Symbol to Noise Ratio (SNR) on X-axis and Symbol Error Rate (SER) on Y-axis.

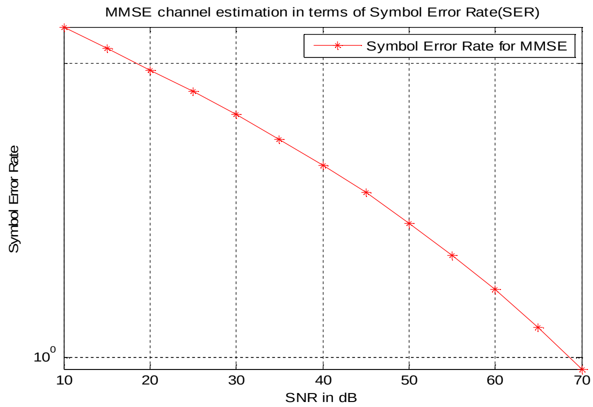


VI.III64-QAM Modulation

i) The power factor is expressed in terms of Symbol to Noise Ratio (SNR) on X-axis and Mean Square Error (MSE) on Y-axis.



ii) The power factor is expressed in terms of Symbol to Noise Ratio (SNR) on X-axis and Symbol Error Rate (SER) on Y-axis.



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VII.CONCLUSION

In the work we focused on the Pilot based MMSE algorithm in which we evaluated parameters like MSE & SER along with the SNR values. The same results we have obtained for the 4-QAM, 8- QAM, 16 QAM & 32-QAM modulation schemes. As we go for higher modulation schemes, definitely results should be better for it. But complexity & number of iterations increases. But the results are not considerably improved for increased complexity & iteration. So the optimal results in consideration with Parameters like SER & MSE along SNR, good results are at 16QAM.Also these values of MSE & SER along with SNR are less as compared to the values of the Blind channel estimation.

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