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Performance Evaluation of Training Based Channel Estimation in MIMO-OFDM Wireless System

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Abstract—In modern wireless communication systems, multiple input multiple output (MIMO) combined with orthogonal frequency division multiplexing (OFDM) can achieve reliable high data rate and better spectral efficiency. 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 Least square (LS) and Minimum mean square (MMSE) estimation algorithms through matlab simulation. The performance of channel estimation techniques LS and MMSE are compared on the basis of mean square error (MSE) for 2x2 and 4x4 MIMO-OFDM system.

Keywords*-MIMO-OFDM, pilot carriers, channel estimation, minimum mean square error.*

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I. INTRODUCTION

The performance of wireless communication systems is mainly governed by the wireless channel environment. The wireless channel is dynamic and unpredictable, which makes an exact analysis of the wireless communication system often difficult. In recent years, optimization of the wireless communication system has become critical with the rapid growth of mobile communication services and emerging broadband mobile Internet access services. In fact the understanding of wireless channels will lay the foundation for the development of high performance and bandwidth-efficient wireless transmission technology. Mobile communication systems transmit bits of information which leads to change of amplitude or phase at the receiver side of mobile system. This results in degradation of the signal quality at the receiver, as the performance of the receiver is highly dependent on the accuracy of the estimated channel. The multipath fading channels cause inter symbol interference (ISI) in the received signal. The detection algorithms should have the knowledge of channel impulse response to remove ISI from the signal at the receiver. The channel estimation is based on the known repeated sequence of bits in every transmission burst and the corresponding received samples.

Orthogonal frequency division multiplexing (OFDM) is a multi-carrier modulation and multiplexing technique which is used to transmit high data rate through wireless channels. The transmitter modulates the message bit 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.

MIMO-OFDM is a new wireless technology which has capability of high rate transmission and robustness against multipath fading. In MIMO system multiple number of transmitters at one end and multiple number of receivers at other end are combined to improve spectrum efficiency, channel capacity and reliability . Space time block coding is used to transmit data across number of antennas at transmitter and receiver to improve reliability of data transfer. The main challenge in MIMO-OFDM is how to obtain channel state information for coherent detection of information symbols. The channel can be estimated by using pilot symbols known to both transmitter and receiver. The different types 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 [3]. Such a blind channel estimation technique has an advantage of not incurring an overhead with training signals. However, it often needs a large number of received symbols to extract statistical properties. The training based channel estimation training symbols are known to both transmitter and receiver. The semi blind channel estimation is a hybrid combination 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 periodically for channel estimation [4]. Since pilot tones are inserted into all subcarriers of pilot symbols with a period in time, the block type pilot arrangement is suitable for slow fading channels. The channel estimations techniques LS and MMSE are compared.

II. MIMO - OFDM SYSTEM

The block diagram of MIMO-OFDM is shown in figure1 MIMO-OFDM system with two transmitting and two receiving antennas is considered for easy analysis. In MIMO-OFDM system the transmitter modulates the message bit sequence in to PSK/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 usually distorted by the channel characteristics. In order to recover the transmitted bits,

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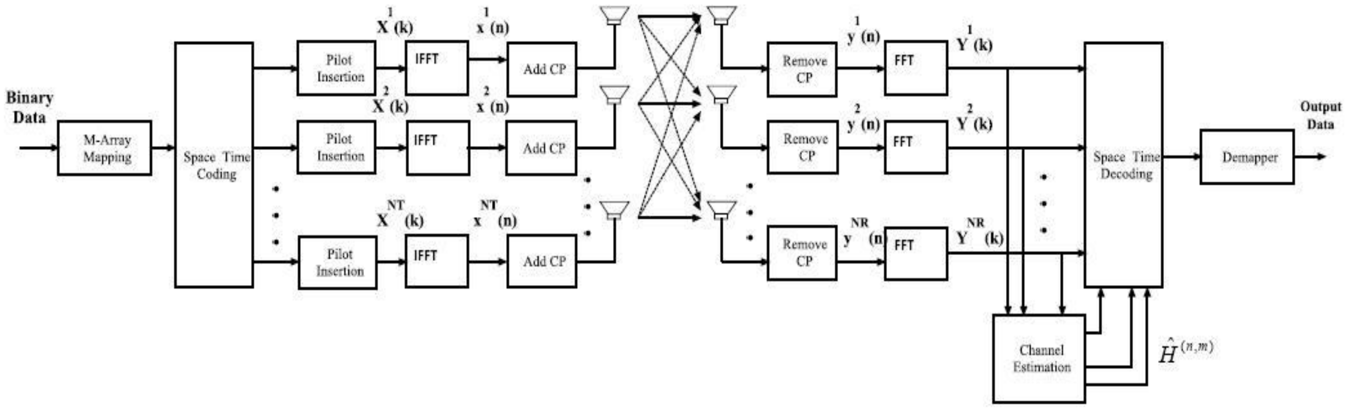

Figure1. MIMO-OFDM System Modelling

the channel effect must be estimated in the receiver. The orthogonality allows each subcarrier component of the received signal to be expressed as the product of the transmitted signal and channel frequency response at the subcarrier. Thus, the transmitted signal can be recovered by estimating the channel response just at each subcarrier. At the receiver cyclic prefix is removed 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. The N_t signals are transmitted over $N_t \times N_r$ transmission paths simultaneously. N_r received signals are combination of N_t transmitted signals and noise. Channel estimation is complex due to more channel coefficients. After message bit sequence undergoes modulation, the space time block coding uses Alamouti algorithm for encoding [5]. The encoding matrix is given as

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

Where

$$X1 = (X[0] \ \ -X^*[1] \ \ X[2] \ -X^*[3] \ \dots \ -X^*[N-1]) \quad (2)$$

$$X2 = (X[1] \ \ X^*[0] \ \ X[3] \ \ X^*[2] \ \dots \ X^*[N-2]) \quad (3)$$

The vectors X1 and X2 are modulated using IFFT and then cyclic prefix is added. Cyclic prefix acts as guard time interval. The transmitting antennas transmits the two modulated signals. The receiving antenna receives the incoming signal 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)

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

In the above equation $[Z_1 \ \cdots \ Z_{N_T}]$ denotes additive white Gaussian noise. $H_{m,n}$ is the channel gain between m^{th} receiver and n^{th} transmitter.

III. MIMO-OFDM CHANNEL ESTIMATION

In training based channel estimation algorithms, pilots are known to both transmitter and receiver that are multiplexed along with data for channel estimation. A block type pilot arrangement is depicted in figure 2. In this type OFDM symbols with pilots at all subcarriers are transmitted periodically for channel estimation. Let S_t denote the period of pilot symbols in time. In order to keep the track of the time varying channel characteristics, the pilot symbols must be placed as frequently as the coherence time. Coherence time is inverse form of Doppler frequency. Since pilot tones are inserted into all subcarriers of pilot symbols the block type pilot arrangement is suitable for frequency selective channels.

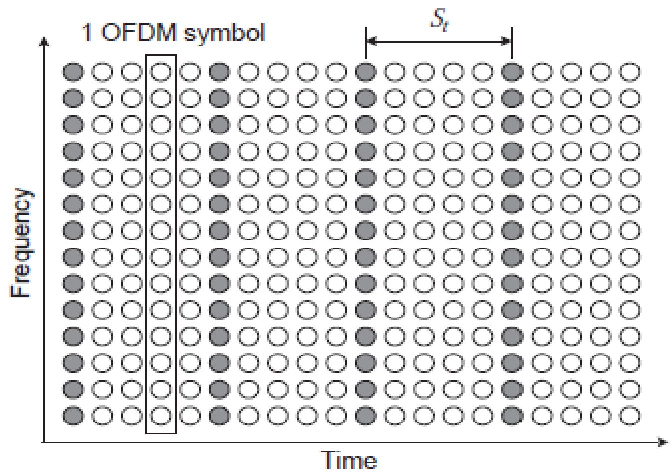

Figure 2. Block Type Pilot

The least square channel estimation for MIMO-OFDM system between n^{th} transmitter and m^{th} receiver is given by the following equation

$$\hat{H}_{LS}{}^{(n,m)} = \frac{Y^{(m)}}{X^{(n)}} \quad (5)$$

$$X = \text{diag}\ \{ X(0), X(1), \dots X(N-1)\} \quad (6)$$

$$Y = \{Y(0), Y(1), \dots Y(N-1)\}^T \quad (7)$$

MMSE channel estimation for MIMO-OFDM system between n^{th} transmitter and m^{th} receiver is

$$\hat{H}_{MMSE}{}^{(n,m)} = F R_{hy} R^{-1}{}_{yy} Y^{(m)} \quad (8)$$

Where

$$R_{hy} = R_{hh}{}^{(m,n)} F^H (X^{(n)})^H \quad (9)$$

$$R_{yy} = X^{(n)} F R_{hh}{}^{(n,m)} F^H (X^{(n)})^H + \sigma^2 I_N \quad (10)$$

are the cross covariance between h and y and auto covariance of y respectively. σ^2 is noise variance and I_N is N X N identity matrix.

$$F = \begin{bmatrix} {W_N}^{00} & \cdots & {W_N}^{0(N-1)} \\ \vdots & \ddots & \vdots \\ {W_N}^{(N-1)0} & \cdots & {W_N}^{(N-1)(N-1)} \end{bmatrix} \quad (11)$$

$$H = [H(0),H(1),\ldots H(N-1)]^T \quad (12)$$

$$W = [W(0),W(1),\ldots W(N-1)]^T \quad (13)$$

n = 1,2….N_T, m = 1,2….N_R and N_T,N_R are number of transmit and receive antennas. X(n) is N X N diagonal matrix and Y(m) is received vector at receiver antenna m.

IV SIMULATION

The parameters used in simulation of MIMO-OFDM system are indicated in Table 1.simulations are carried out for different signal to noise ratios.

Parameters	Specifications
Signal Constellation	QAM
FFT Size	64
Pilot Ratio	¼
Pilot Type	Block
Guard Interval	16
Guard Type	Cyclic Extension
Channel Model	Rayleigh Fading
No of Antennas	2x2,4x4
Channel Estimation	LS,MMSE

The performance of MIMO-OFDM is evaluated by Mean Square Error. The instantaneous mean square error is defined as average error with in OFDM block that can be expressed as

$$MSE = \frac{1}{N}\sum_{K=1}^{N} |H(k) - H_e(k)|^2 \quad (14)$$

Where K is the index of the subcarrier and $H_e(k)$ is estimated by the value of channel estimation.

Figure 3 shows the mean square error for LS channel estimation algorithm of 2x2 MIMO-OFDM. It is observed that LS has high MSE compared to MMSE channel estimation 2x2 MIMO-OFDM system.

Figure 4 shows the mean square error for MMSE channel estimation algorithms of 2x2 MIMO-OFDM. It is observed that MMSE has low MSE compared to LS channel estimation in 2x2 MIMO-OFDM system.

Figure 5 shows the mean square error for LS channel estimation algorithms of 4x4 MIMO-OFDM. It is observed that LS has high MSE compared to MMSE channel estimation in 4x4 MIMO-OFDM system.

Figure 6 shows the mean square error for MMSE channel estimation algorithms of 4x4 MIMO-OFDM. It is observed that MMSE has low MSE compared to LS channel estimation in 4x4 MIMO-OFDM system.

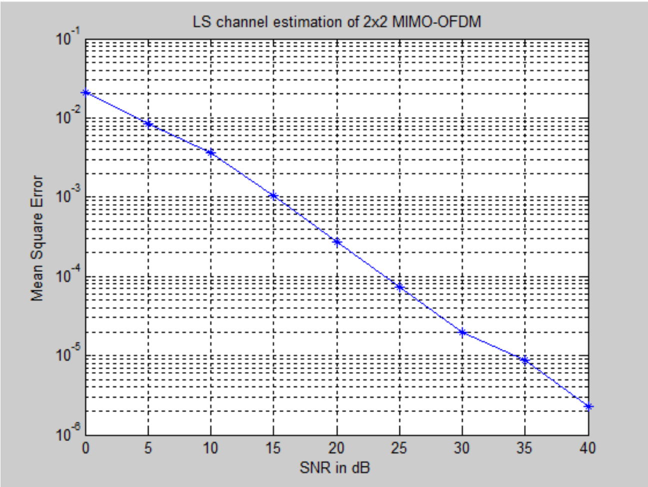

Figure3. MSE for LS estimation of 2x2 MIMO-OFDM system

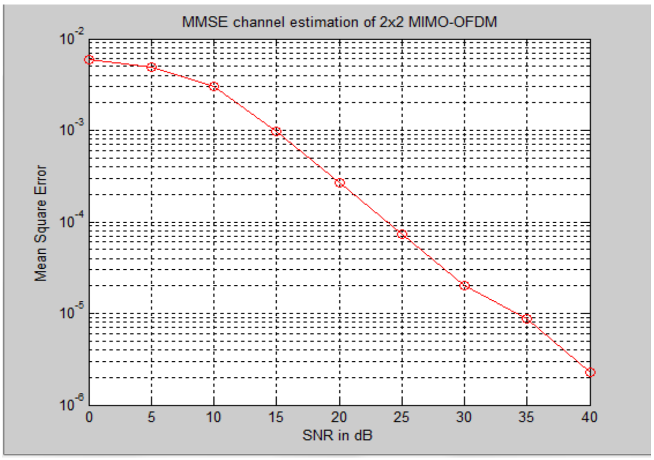

Figure 4 . MSE for MMSE estimation of 2x2 MIMO-OFDM system

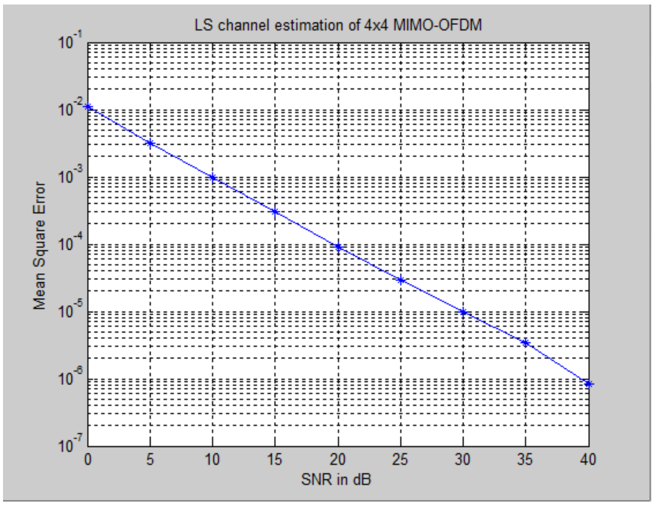

Figure 5. MSE for LS estimation of 4x4 MIMO-OFDM system

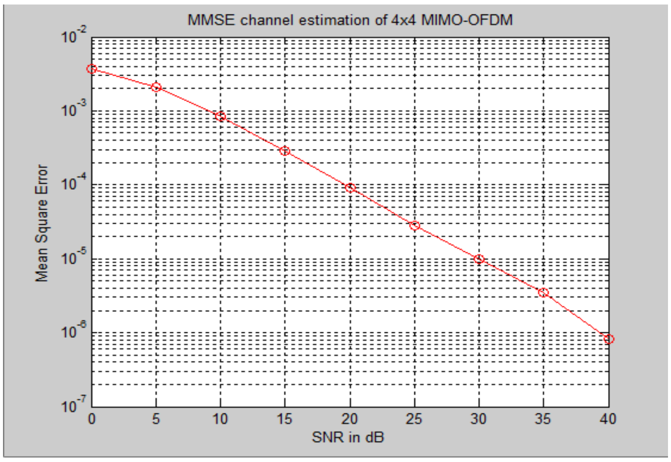

Figure 6 . MSE for MMSE estimation of 4x4 MIMO-OFDM system

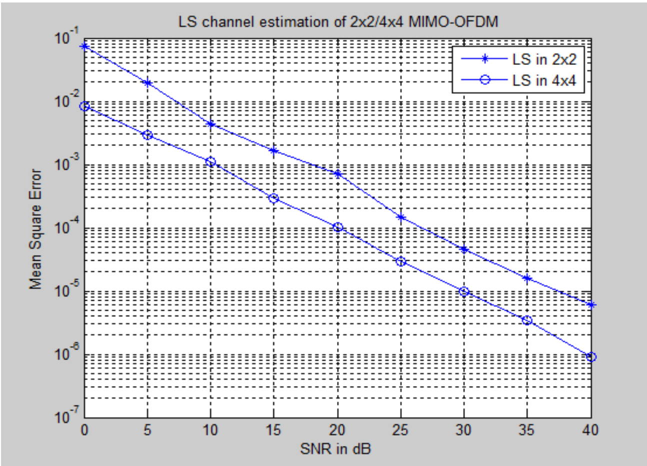

Figure 7 . MSE for LS estimation of 2x2 and 4x4 MIMO-OFDM system

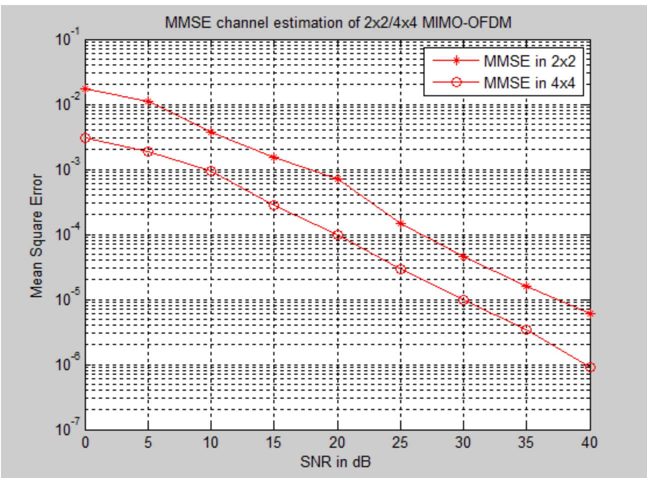

Figure 8 . MSE for MMSE estimation of 2x2 and 4x4 MIMO-OFDM system

Figure 7 shows the mean square error for LS channel estimation algorithm of 2x2 and 4x4 MIMO-OFDM. It is observed that LS for 4x4 MIMO-OFDM has low MSE compared to 2x2 MIMO-OFDM system.

Figure 8 shows the mean square error for MMSE channel estimation algorithm of 2x2 and 4x4 MIMO-OFDM. It is observed that MMSE for 4x4 MIMO-OFDM has low MSE compared to 2x2 MIMO-OFDM system.

V. CONCLUSION

In this paper channel estimation based on block type pilot arrangement for 2x2 and 4x4 MIMO-OFDM system for a Rayleigh fading channel are compared. The two channel estimation algorithms LS and MMSE are applied and simulation is performed. The simulation results shows that LS and MMSE estimation has less MSE in 4x4 than 2x2 MIMO-OFDM system. MMSE channel estimation has less MSE than LS in 2x2 and 4x4 MIMO-OFDM system. So MMSE channel estimator has better performance than LS channel estimator.

REFERENCES

[1]. Ramjee Prasad, “ OFDM for Wireless Communications Systems”, Artech House, Inc Publications.

[2]. Kala Praveen Bagadi, Prof. Susmita Das “ MIMO OFDM channel estimation using pilot carriers”, International Journal of computer applications, Vol 2,No.3, May2010.

[3]. A Petropulu, R. Zhang and R.Lin “Blind OFDM channel estimation through simple linear precoding” , IEEE Transactions on Wireless Communications, Vol.3,No.2,March 2004.

[4]. Osvaldo Simeone, Yesheskel Bar-Ness, Umberto Spangnolini, “Pilot-Based Channel Estimation for OFDM systems by Tracking the Delay-Subspace”, IEEE Transactions on Wireless Communications, Vol3, No.1,January 2004.

[5]. Siavash M. Almouti, “A Simple Transmit diversity Technique for Wireless Communication,” IEEE Journal on Select Areas in Communications, Vol 16, No. 8, October 1998.

[6]. J.J Van de Beek, O. Edfors, M. Sandell, S.K. Wilson and P.O.Borjesson, “On Channel estimation in OFDM systems,” in Proc, IEEE 45th Vehicular Technology Conf, Chicago,IL,July.1995.

[7]. Ezio Bigileri, Robert Calderbank, Anthony Constantinides, Andrea Goldsmith, Arogyaswami Paulraj, H. Vincent Poor,” MIMO Wireless Communication”, Cambridge Press.

[8]. D. Marvares Teran, Rafael P, Toress, “Space-time code selection for OFDM-MISO system”, ELSEVIER journal on computer communications, Vol.32, Issue .3, 25 February 2009.

[9]. Pan Pei-sheng, Zheng Bao-yu, “Channel estimation in space and frequency domain for MIMO-OFDM systems”,ELSEVIER journal of China Universities of Posts and Telecommunications, Vol.16,No.3,June 2009.

[10]. Mohammad Torabi, “Antenna selection for MIMO-OFDM systems”, ELSEVIER journal on Signal Processing, Vol.88,2008.

[11]. Sterba J., Kocur D.,Radioelektronika “Pilot symbol aided channel estimation for OFDM system in frequency selective Rayleig fading channel “ , 19th International Conference Radioelektronika, pp. 77-80, 2009.

[12]. Kamran Arshad and Dr. A.U.H.Sheikh, “Arrangement of Pilot Tones in wireless OFDM Systems”, 14th IEEE International Symposium, PIMRC 2003, Beijing, China.

[13]. L.H.Xing , “Channel Estimation for Transmitter Diversity OFDM Systems “,IEEE Conf. Industrial Applications pp. 1-4, 2006.

[14]. Mingqi Li,Yulin Liu,Qicong Peng “Performance Comparison Between Two Pilot Symbol-aided Channel Estimation Schemes for OFDM” ,Signal Design & its Applications in Communications, IWSDA 2007,3rd International workshop, pp 303 – 306, 2007.

[15]. T. Rappaport, ‘Wireless Communications, Principles and Practice’ Prentice Hall, 2009.