Channel estimation in MIMO-OFDM systems based on comparative methods by LMS algorithm

Navid daryasafar, Aboozar lashkari, Babak ehyaee

[1]**Department of Communication, Bushehr Branch, Islamic Azad University Bushehr,** Iran

[2]**Department of Communication, Bushehr Branch, Islamic Azad University Bushehr, Iran**

[3]**Department of Communication, Bushehr Branch, Islamic Azad University Bushehr, Iran**

Abstract

In mobile telecommunication systems, a channel estimating method which is able to follow its changes at any moment, quickly, precisely and with less calculating operations, is a mater of high significance. The aim of this paper is to investigate and propose a channel estimation method for MIMO-OFDM systems based on comparative methods. According to this, with investigating the channel estimation method, we can design optimum training courses for these systems and introduce related comparative methods based on LMS algorithm. The efficiency of suggested LMS algorithm can be investigated by simulation and the results of estimation will come to a comparison.

Keywords: *Multi-Input Multi-Output systems, Channel Estimation ,LS algorithm, LMS algorithm*.

1. Introduction

MIMO-OFDM systems are one of the systems which have become the basis of many communication researches nowadays. A system is with several high speed inputs and outputs in sending information or suitable diversity between transmitter and receiver; however the estimation of the channel in this connection is complex. In order to reveal the coherent of received signals, digital communication systems must have an exact estimation of the situation of exchange channel between transmitter and receiver. Since increasing the number of transmitter and receiver antennas causes an increase in the number of unknowns (coefficients of the channel between both antennas of transmitter and receiver) the estimation of channels in multi-antenna systems is a lot more challenging than in one-antenna ones. [1]

To model the effects of ISI channel, a comparative filter can be applied in order to decode the obtained information through an optimum method. This paper presents a LMS based method for simultaneous estimation of all sub-channels, which provides appropriate channel estimation, applying simple recurrence relations.

Further, in the second chapter the MIMO OFDM systems will be introduced. In the third chapter, the channel coefficients estimation methods and in the fourth one the suggested algorithm for fading channel coefficients estimation in MIMO-OFDM systems will be described and finally, the simulation results will indicate the performance of suggested algorithm.

2. Introduction of MIMO OFDM systems

In a traditional wireless communication system, provided that the bandwidth is constant, there is no possibility of increasing the sending rate of information. In this kind of situation, only diversity methods can be used to improve the quality of revealing. In designing communication systems, bandwidth, information sending rate and software-hardware complexities are the important parameters. To expand the new generation of communication systems, methods such as MIMO, OFDM and integrating them together as MIMO-OFDM, are suggested. OFDM is used in numerous wireless transmission standards nowadays (DAB, DVB-T, WiMAX IEEE 802.16, ADSL, WLAN IEEE 802.11a/g, Home Plug AV or DS2 200 aka "Home Bone"). The OFDM modulation transforms a broadband, frequency-selective channel into a multiplicity of parallel narrow-band single channels. A guard interval (called Cyclic Prefix CP) is inserted between the individual symbols. This guard interval must be temporally long enough to compensate for jitter in the transmission channel. Transmitted OFDM symbols experience different delays through the transmission channel. The variation of these delays at the receiving location is called jitter. The appearance of inter-symbol interference (ISI) can thus be prevented. It has been shown in that OFDM can be favourably combined with multiple antennas on the sending side as well as the receiving side to increase diversity gain and/or transmission capacity in time-varying and frequency-selective channels.

The high intrinsic resistance of OFDM against the ISI event and its suitable function against fading destructive event, besides the high rate of information sending of MIMO, creates a very efficient complex in accession toward the fourth generation of wireless communication's demands. Like OFDM systems, the MIMO-OFDM systems have a great deal of sensitivity toward synchronization errors. Again, according to the increase in number of unknowns, estimating the channel in these systems are more complex than estimating channel in one antenna systems [2]. Diagram block of one kind of MIMO-OFDM systems, is shown in the figure1.

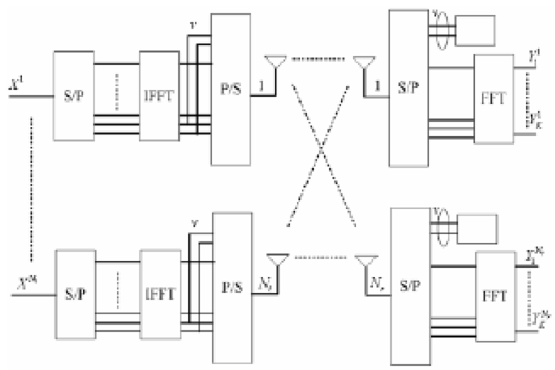

Fig. 1 Displaying a MIMO-OFDM system.

According to the figure, the information in each antenna is sent after IDFT actions and addition of (CP) cyclic prefix. Each receiver antenna receives sum of noises and signals sent by the transmitter's antenna. In each receiver antenna the revealing is done after removing CP and DFT actions.

3. Channel estimation methods in MIMO OFDM systems

The major considered estimating channel methods are as follows:

A. Using educational sequence methods

By putting samples in the sent symbol which are known by the receiver, we can reach the channel's domain which is multiplied by sum symbol and shift results. Now by using the channels reached coefficients, we can reveal the rest of symbol samples which are the desired inputs and the receiver is unaware of them [3].

B. Blind methods

In this method which has no need of educational samples, using the covariance matrix, the receiver estimates the coefficients of channel and reveals the sent inputs by using them [4].

C. Half blind methods

In this method the between up between properties of the two previous methods are used [5].

4. Channel's coefficients estimation algorithm

4.1 LS Channel Estimation

The combination of orthogonal frequency division multiplexing (OFDM) with space-time coding has received much attention recently to combat multipath delay spread and increase system capacity . Channel parameters are needed in order to coherently decode the transmitted signal. Least square (LS) channel estimation for MIMO-OFDM systems has been addressed in . But if the multipaths are not sample-spaced, the well known leakage problem for DFT based channel estimation . induces an irreducible error floor for estimation error. To reduce this error floor, more taps have to be used, which not only increases computational complexity but also makes estimation problem more ill-conditioned and thus enhances noise. As an alternative, channel estimation algorithm based on parametric model has been proposed in and extended to MIMO-OFDM in .
Channel information is required at receiver for signal detection. However, There are different methods of channel estimation such as pilot aided (Li, 2002) and blind (Gao and Nallanathan, 2007) approaches, the first method is chosen as a channel estimation method in this study due to its less complexity. According to sampling theory (Oppenheim and Schafer, 1999), Pilots are inserted equal-spaced among subcarriers in frequency domain at transmitter, which are known at receiver and will be extracted to estimate channel at pilot subcarriers and interpolation is implemented for channel estimation in another subcarriers. In the analysis, channel is estimated with LS (Coleri *et al*., 2002) method at pilots, then linear interpolation is used to complete the estimation (Coleri *et al*., 2002; Hsieh and Wei, 1998). **Receiver designing:** At the receiver, nr × nt sets of extracted received pilot tones are used for channel estimation, which LS method is chosen due to its simplicity. The standard formula for this approach at mth symbol is computed as:

$$H_{LS}(m) = ((x^p(m))^H x^p(m))^{-1} (x^p(m))^H Y^p(m) \quad (1)$$

where, XP(m) and YP(m) respectively show the transmitted and received pilots.

A MIMO-OFDM system is supposed, with N transmitter antennas and M receiver antennas and K sub carrier which has the following diagram block.

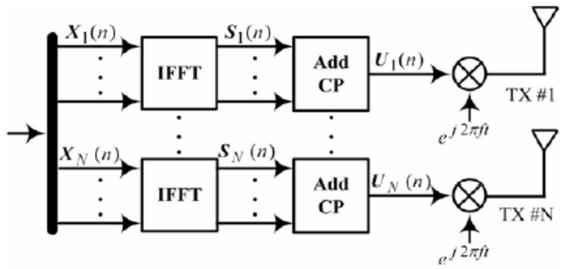

Fig. 2 Diagram block of MIMO-OFDM system's transmitter.

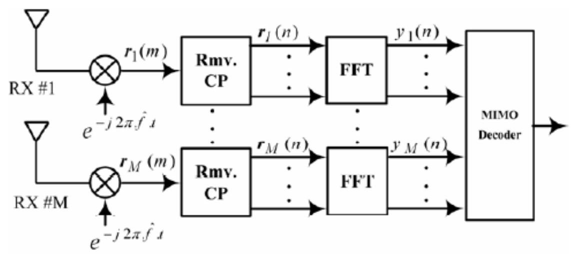

Fig. 3 Diagram block of MIMO-OFDM system's receiver.

For a 2*2 MIMO-OFDM channel, the impact response under the channel between ith transmitter antenna and jth receiver is represented by $h_{i,j}$:

H (

In the receiver, the received signal under the kth carrier after the Fourier transform is:

$$yj(K) = \sum_{i=1}^{MT}\big(Xi(k)Hi,j(k)\big) + Wj(k) \quad (3)$$

Where M_T is the number of transmitter antennas, $w_j(K)$ represents White Gaussian Noise with an average of 0 for the jth receiver antenna in the kth sub-carrier. And for a 2*2 MIMO-OFDM system we have:

$$\underline{y_1}_{N\times1} = \big[\underline{X_1} \quad \underline{X_2}\big]\underline{WL}\,\underline{h_1} = \underline{A}_{N\times2L}\underline{h_1}_{2L\times1} + \underline{Z_1}_{N\times1} \quad (4)$$

,

$$\underline{y_2}_{N\times1} = \big[\underline{X_1} \quad \underline{X_2}\big]\underline{WL}\,\underline{h_2} = \underline{A}_{N\times2L}\underline{h_2}_{2L\times1} + \underline{Z_2}_{N\times1} \quad (5)$$

Where:

$$h1=[h11;h21] \; h2=[h12;h22] \quad (6)$$

And $\underline{WL}$ is a matrix N × L consisting of all $e^{-j\frac{2\pi}{N}K_L L}$.

That in the end Estimated channel coefficients is as follows:

$$if: \tilde{k} \in pilot_{2L} \rightarrow \underline{\hat{h}_1}_{2L\times1} = A^{-1}(\tilde{k})y_1(\tilde{k}), \underline{\hat{h}_2}_{2L\times1} = A^{-1}(\tilde{k})y_2(\tilde{k}) \quad (7)$$

4.2 Channel's coefficients estimation with LMS algorithm

There are different iterative algorithms which are used to improve channel estimation and various methods are obtained as initial estimation. Also estimation in each iteration, can be used as side information and feed back to system to achieve better result in next iteration.

As illustrated in Fig. 4, LMS algorithm is applied to receiver and the channel which was estimated in each iteration would be used for next iteration, additionally the output signal is fed to source signal for next channel estimation. Another important factor in channel estimation through this method is μ which influences on estimation and should be precisely chosen[6].

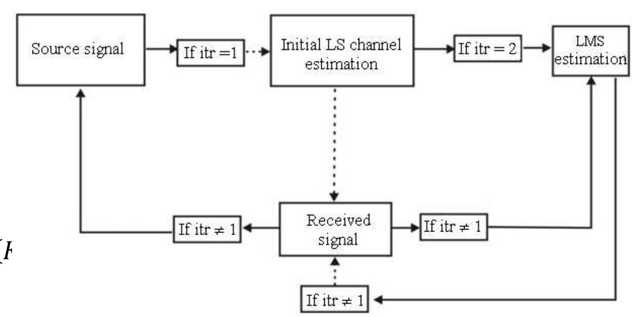

Fig. 4 Implementing LMS algorithm in proposed receiver.

In this method the coefficients of the vector H_n are obtained applying LMS recurrence as following:

$$\hat{H}_n = \hat{H}_{n-1} - \mu \times e \times X^* \quad (8)$$

Where

n = The iteration state

e = The signal error

μ = A coefficient between 0-1

4.3 Simulation results

In this chapter, a MIMO-OFDM system with 2 transmitter antennas and 2 receiver ones is used for the simulation. The assumed system has a QPSK modulation. The total number of sub-carriers, N, is 64 and L is the tap of channel.

The simulations in channel estimation in SISO-OFDM and MIMO-OFDM systems are as follows:

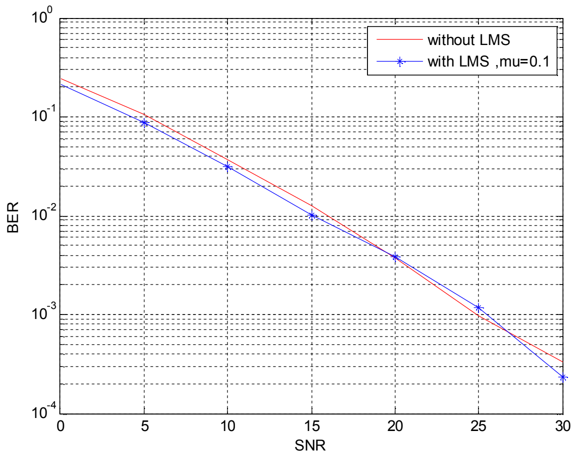

Fig. 5 Channel estimation in SISO-OFDM systems L=5 without synchronization and LMS algorithm μ=0. 1.

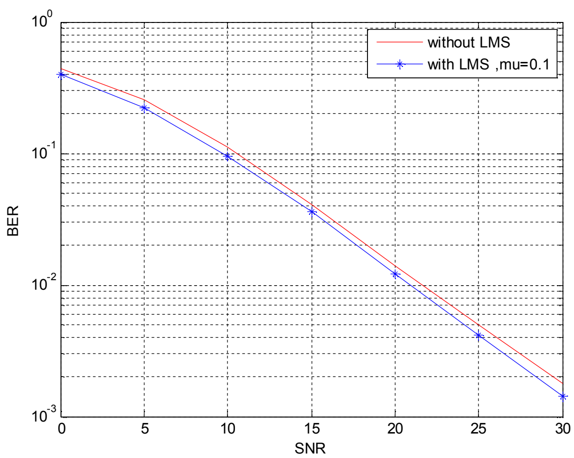

Fig. 6 Channel estimation in SISO-OFDM systems L=5 with synchronization and LMS algorithm μ=0. 1.

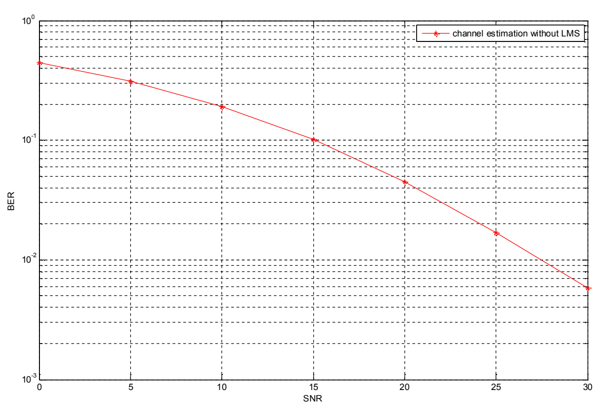

Fig. 7 Channel estimation in 2*2 MIMO-OFDM systems L=4 without synchronization.

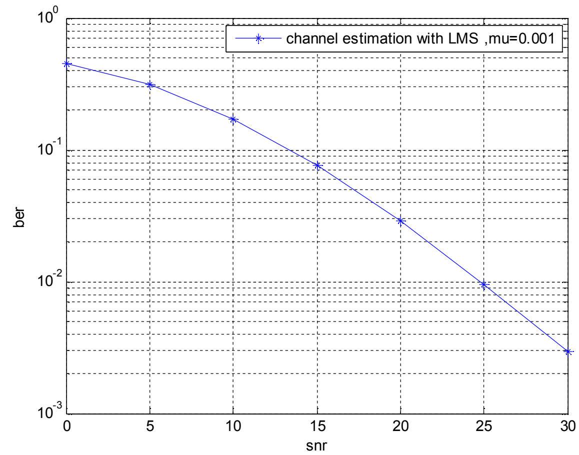

Fig. 8 Channel estimation in 2*2 MIMO-OFDM systems L=4 without synchronization,μ=0.001.

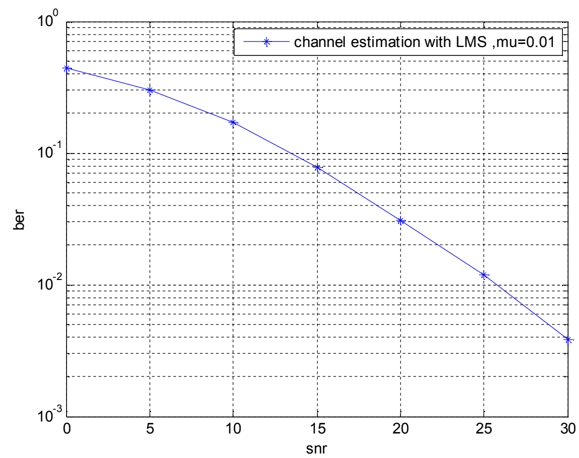

Fig. 9 Channel estimation in 2*2 MIMO-OFDM systems L=4 without synchronization,μ=0.01.

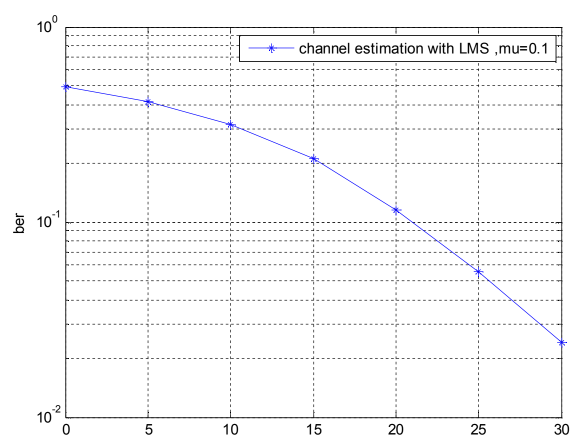

Fig. 10 Channel estimation in 2*2 MIMO-OFDM systems L=4 without synchronization,μ=0.1.

Each of the figures 5 to 10 Show channel estimation in SISO and MIMO-OFDM systems.Figures 6,7 show channel estimation with LS method in MIMO-OFDM systems.Figures 8,9,10 show channel estimation with LMS algorithm for μ=0.001,0.01,0.1 .

5. Conclusions

LS method offers accurate estimation of channel.In this paper LS method was used for initial channel estimation. For improving accuracy of channel estimation, LMS algorithm was added to receiver which includes a feedback of output and improves the BER performance of system .
The channel estimation with LMS algorithm can be closed to LS method With a careful choice of μ . In the performed simulations it is observed that with a careful choice of μ , the channel estimation will be similar to the methods of estimating LS.
In this paper, the channel estimation is performed for a MIMO-OFDM system through the LMS suggested method. The LMS method is extremely dependant to parameter, μ. This method presents appropriate channel estimation through applying simple recurrence relations.

References

[1] X. Ma, M.K. Oh, G. B. Giannakis, and D.J.Park, "Hopping Pilots for Estimation of Frequency-Offset and Multiantenna Channels in MIMO- OFDM", IEEE Trans. On commun., vol. 53, no. 1, pp. 162-172, Jan. 2005.

[2] G. J. Foschini and M. Gans, “On limits of wireless communications in a fading environment when using multiple antennas,” Wireless Pers. Commun., vol. 6, pp. 311–355, March 1998.

[3] Jin-Goog Kim and Jong-Tae Lim ," MAP-Based Channel Estimation for MIMO–OFDM Over Fast Rayleigh Fading Channels " , 2008 .

[4] Feifei Gao, Yonghong Zeng, Arumugam Nallanathan, Tung-Sang Ng, , " Robust Subspace Blind Channel Estimation for Cyclic Prefixed MIMO OFDM Systems: Algorithm,Identifiability and Performance Analysis " , 2008.

[5] Feng Wan, W.-P. ZhuM. N. S. Swamy, " A Semiblind Channel Estimation Approach for MIMO–OFDM Systems " ,2008.

[6] Mona Nasseri and, Hamidreza Bakhshi, “Iterative Channel Estimation Algorithm in Multiple Input Multiple Output Orthogonal Frequency Division Multiplexing Systems”, Journal of Computer Science, , 2010.

Navid Daryasafar was born in Bushehr ,Iran.He received Bachelor and Master degrees in Electrical-Telecommunication engineering from Islamic Azad University , Bushehr, Iran.

Aboozar Lashkari was born in Bushehr ,Iran.He received Bachelor and Master degrees in Electrical-Telecommunication engineering from Islamic Azad University , Bushehr, Iran.

Babak Ehyaee was born in Bushehr ,Iran.He received Bachelor and Master degrees in Electrical-Telecommunication engineering from Islamic Azad University , Bushehr, Iran.