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# A New Pilot Sequence Insertion Method for Channel Estimation Based on STBC MIMO OFDM System

**Neenu Sharma[1], Sanjay Bhardwaj[2]**

[1, 2]Shoolini University of Biotechnology and Management Sciences, Department of Electronics and Communication Engineering, Solan, Himachal Pradesh, 173229, India

**Abstract:** ***In this paper, a pilot based channel estimation for multiple input multiple output (MIMO) with orthogonal frequency division multiplexing (OFDM) with space time block coding is studied. The MIMO-OFDM system is used to boost the high data rates and reduces the inter carrier interferences (ICI). The amalgam of multiple input multiple output (MIMO) with orthogonal frequency division multiplexing (OFDM) provides admirable data rate in wireless channel. In multiple input multiple output system and orthogonal frequency division multiplexing (MIMO-OFDM) system, the channel state information is very acceptable. So channel state information sometime caviling the capability of the system and the correct signal cannot receive properly at the receiver side. So the training sequences are sending along with the data to achieve the good and efficient data at the receiver side. There are various method to insert the pilot with the data. The training pilot symbols are sending along with the data symbols at the time interval. In order to reduce the training cycle, there is iterative method used to insert the pilot symbols. The given method shows that the mean square method and bit error rate is reduced and it gives better MSE and BER.***

**Keywords:** STBC, BER, MSE, SNR

## 1. Introduction

Wireless communication beholds as the most important development technique in the modern technologies. Wireless communication system high speed of data is achieved and it can also provide a low cost and high quality of services [1]. In wireless communication system there is fading and attenuation occurs and thus reduces the system capacity. In communication system frequency division multiplexing access (FDMA), Time division multiplexing access (TDMA) and Code division multiplexing access (CDMA) is used to transmit the data but due to the large bandwidth requirement they are less convenient to the OFDM system [2]. Multiple input multiple output (MIMO) has been consider because MIMO has a good potential to increases the system capacity and it can increases the speed of data rates. In MIMO there is a multiple antenna at transmitter and receiver side has been placed and thus increased the potential of the system. In MIMO system there is multipath channels can be occur so at the receiver side the signal can be received at different time period and hence the data can be off track and fading can be occur. To reduce the effect of frequency selective fading, orthogonal frequency division multiplexing (OFDM) with multiple input multiple output (MIMO) system has been proposed. Orthogonal frequency division multiplexing (OFDM) is a technique through which the data rates are increases rapidly and it is imperative in frequency selective fading channels [3]. Orthogonal frequency division multiplexing (OFDM) is capable with higher bandwidth efficiency and its robustness to multipath delays [4]. Orthogonal frequency division multiplexing (OFDM) system also exploits coherent detection which entail accurate information on the channel impulse response [5]. In orthogonal frequency division multiplexing (OFDM) the frequency selective channels can be converted into a number of parallel flat channels. OFDM has many advantages such that it is strong against frequency selective fading channels and it can converts these channels into number of small flat subcarriers and deflects multipath fading [6]. In the MIMO-OFDM system the channel state information is very important so that at the receiver side the data is decoded correctly [7]. There are various method for channel estimation such as blind channel estimation, pilot based channel estimation and semi blind channel estimation [1], [2]. The channel estimation also divided into two models such as non model based and model based and hence in the non model based channel estimation there is large complexity as compared to the model based channel estimation [8]. In the pilot based channel estimation the training sequences are sending along with the data with the period of interval. The pilots are inserted into all of the subcarriers of one OFDM symbol with a certain period of time or pilot symbols are sending into each OFDM symbols. Space time block coding is a newly proposed method used to combines the signal at the receiver side with multiple antenna using coding techniques and provide a fluent gain and good efficiency in MIMO-OFDM system [9]. The space time block coding can uses the transmit diversity for the OFDM system and it can gives the best copout between data rates, constellation sizes and diversity. STBC is used in the frequency domain to obtain the orthogonal channel estimation from the different transmission antenna with specific pilot pattern in FFT grid [10]. STBC also provides simple implementation algorithms and improves the reliability [11]. STBC and MIMO system has been used in IEEE 802.11n standards so that higher data rate can be achieved and it can provide a more accurate data than the single antenna [12]. In the STBC pilot pattern there is more number of OFDM symbols are used and hence it increases the bit error rate (BER) and mean square error rate (MSE). So there is new method is proposed to reduces the bit error rate and mean square error rate.

This paper introduces the iteration method for sending the pilot symbols to attain the channel state information. In this paper bit error rate (BER) and mean square error rate (MSE) is reduced by using the scheduling algorithms. In this paper the 2 by 2 antennas are used. The bit error rate ratio (BER) and the mean square error rate ratio (MSE) is reduced by the proposed method.

The rest of the paper can contain: section 2$^{nd}$ contain MIMO-OFDM system. Section 3$^{rd}$ contains LS channel estimation. Section 4$^{th}$ contains the pilot sequence method for channel estimation. Section 5$^{th}$ contains simulation and results. Section 6$^{th}$ contain the conclusion

## 2. System Model Description

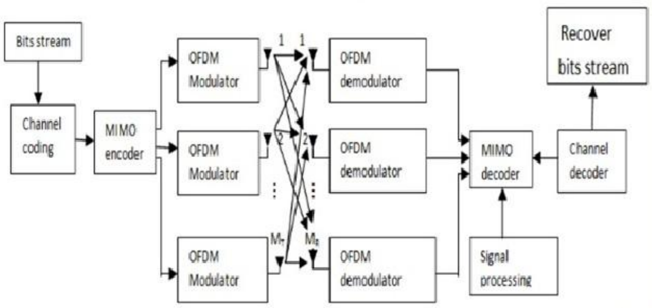


**Figure 1:** MIMO-OFDM System Model

OFDM is a technique through which the multiple paths fading is reduced and the ICI is also reduced. In the OFDM system the data is divided into the number of parallel data and then the data is sending on the AWGN channel. Now at the k subcarrier and n transmission time can be expressed as,

$$Y[n,k] = H[n,k]X[n,k] + N[n,k]$$

Where,
X[n,k] = Transmitted signal on kth subcarrier at the time interval n., N[n,k] = Additive complex Gaussian noise with Zero mean and variance $\sigma_n^2$

So the matrix is given as

$$Y[n] = H[n]X[n] + N[n]$$

Where

$$Y[n] = (Y[n,0],.............Y[n,kT]^T)$$

$$H[n] = (H[n,0],.............H[n,kT]^T)$$

$$X[n] = \begin{bmatrix} X[n,0] & \dots & 0 \\ \vdots & \ddots & \vdots \\ 0 & \dots & X[n,kT] \end{bmatrix}$$

$$N[n] = (N[n,0],.............N[n,kT]^T)$$

The channel impulse response is constant over the one OFDM symbols so that it can be given as,

$$H[n,k] = \sum_{m-1}^{\lambda} h_m(n) e^{-j2\pi k \tau_m / T_S}$$

The signal is send to the multipath fading channel and the received OFDM signal can be denoted as,

$$y(t) = \sum_{m-1}^{\lambda} h_m(t) x(t - \tau_m) + n(t)$$

MIMO-OFDM system plays an important role in the 4G and next generation communication system. Let $T_x$ is the Transmitter antenna and $R_x$ is the receiver antenna. Now at each time slot t, the signal $U_t^i, i = 1,2,3,.......n$

The path gain from transmit antenna i to receive antenna j is defined as $\beta_{i,j}$. Now at the receiver antenna it becomes;

$$r_i^j = \sum_{i=1}^{n} \beta_{i,j} U_t^i + W_t^j$$

Where $W_t^j$ = independent samples of zero mean Gaussian random variables with the variance of 0.5.

To find the pilot symbols and the data symbols at receiver side the least square (LS) and linear minimum mean square (LMMSE) algorithms is used and hence using this algorithm the complexity of the system is increases. Space time block coding is used at transmitter side and decoded at the receiver side.

The least-square (LS) channel estimation method finds the channel estimate ^ H in such a way that the following cost function is minimized:

$$j(\hat{H}) = Y - X\hat{H}^{\,2}$$

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

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

Now the least square become;

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

The mean-square error (MSE) of this LS channel estimate is given as

$$MSE_{LS} = E\{(H - \hat{H}_{LS})^H (H - H_{LS})\}$$

$$= E\{(H - X^{-1}Y)^H (H - X^{-1}Y)\}$$

$$= \frac{\sigma_Z^2}{\sigma_X^2}$$

## 3. Space Time Block Coding

The combination of STBC with the OFDM increase the data speed and makes the interest in the future wireless communication system. In order to fulfill this condition, the channel state information is very important. In the STBC the data is first encoded and the encoded data is converted into n streams which are simultaneously transmitted with n transmitted antenna. It can also be shown that space time block coding (STBC) provides best performance with no extra processing. STBC also improves the reliability of the transmission system. In the Alamouti encoder, two consecutive symbols x1 and x2 are encoded with the following space-time codeword matrix.

$$X = \begin{bmatrix} x_1 & x_2 \\ -x_2^{*} & x_1^{*} \end{bmatrix}$$

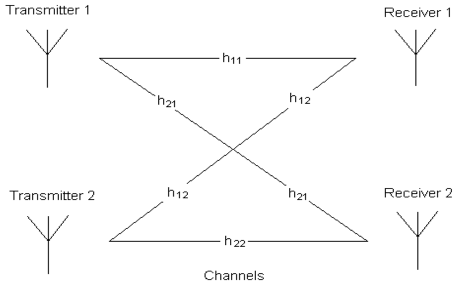


**Figure 2:** Two transmit antenna and two receive antenna

Now the received vector after first time slot will be,

$$\begin{bmatrix} y_{11} \\ y_{12} \end{bmatrix} = \begin{bmatrix} h_{11} & h_{12} \\ h_{21} & h_{22} \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} w_{11} \\ w_{12} \end{bmatrix}$$

Now the received vector after the second timeslot will be,

$$\begin{bmatrix} y_{21} \\ y_{22} \end{bmatrix} = \begin{bmatrix} h_{11} & h_{12} \\ h_{21} & h_{22} \end{bmatrix} \begin{bmatrix} -x_2^{*} \\ x_1^{*} \end{bmatrix} + \begin{bmatrix} w_{21} \\ w_{22} \end{bmatrix}$$

$\begin{bmatrix} y_{11} \\ y_{12} \end{bmatrix}$ = received vector in 1st time slot by antenna 1 and 2.

$\begin{bmatrix} y_{21} \\ y_{22} \end{bmatrix}$ = received vector in 2nd time slot by antenna 1 and 2.

$\begin{bmatrix} w_{11} \\ w_{12} \end{bmatrix}$ = noise vector during time slot 1.

$\begin{bmatrix} w_{21} \\ w_{22} \end{bmatrix}$ = noise vector during time slot 2

Then,

$$y = Hx + w$$

$$y = \begin{bmatrix} y_{11} & y_{12} & y_{21} & y_{22} \end{bmatrix}^T$$

$$x = \begin{bmatrix} x_1 & x_2 \end{bmatrix}^T$$

$$w = \begin{bmatrix} w_{11} & w_{12} & w_{21}^{*} & w_{22}^{*} \end{bmatrix}^T$$

By combining the above equations, we get,

$$\begin{bmatrix} y_{11} \\ y_{12} \\ y_{21}^{*} \\ y_{22}^{*} \end{bmatrix} = \begin{bmatrix} h_{11} & h_{12} \\ h_{21} & h_{22} \\ h_{12}^{*} & -h_{11}^{*} \\ h_{22}^{*} & -h_{21}^{*} \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} w_{11} \\ w_{12} \\ w_{21}^{*} \\ w_{22}^{*} \end{bmatrix}$$

The transmitted information after modulation is given to the space time encoder and the space time encoder consists of two Transmitter antennas which can separate the information. Each transmitter and receiver antenna pair contains a channel and they are represented by different channel coefficients.

The rate of the code is defined as:

R=N/T

Where N =symbols and T= time slots

## 4. A Pilot Based Sequence Method for Channel Estimation

In this proposed method the data is first send to the serial to parallel converter and after that this a data is modulated by different data modulation schemes such as QPSK, BPSK, 16 QAM etc. The 16 QAM modulation is used in this method. In the 16 QAM modulation the four symbols are send and the symbol rate is ¼ is snatched. Then the pilot symbols are inserted.

$$SNR_{n-1}^{k} = \left| \frac{|g_{n-1}^{k}|}{|\sum_{total=n-1}^{k}|} \right.$$

Where,
SNR= signal to noise ratio, n= number of data length, k= number of subcarriers, g= number of input bits

## 5. Simulation and Results

The simulation parameters are given in table 1

**Table 1:** Simulation Parameters

| System Parameter | Parameter Value |
|---|---|
| System Software | MATLAB |
| Modulation | 16 QAM |
| Encoder | STBC |
| Channel | AWGN |
| Number of Sub Carriers | 1024 |
| Number of Multipath | 10 |

In the given figures it can be shown that graph between the signal to noise ratio (SNR) and bit error rate (BER) using the 16 QAM modulation. The additive white Gaussian noise (AWGN) channel is consider and the results shows that when the signal to noise ratio is 20dB than the bit error rate is $10^{-4}$

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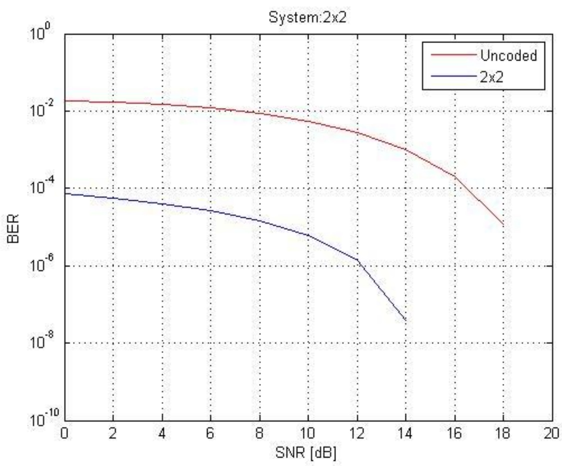


**Figure 3:** Graph plot between SNR and BER using 2 transmit antenna and 2 receive antenna with AWGN channel

The pilots are inserted with the modulation data symbols at the using pilot duration of 4 symbols and the data is converted into time domain using the IFFT and then the cyclic prefix is added. At the receiver side the cyclic prefix is removed and then FFT is applied. The received pilots are known by using the least square method (LS). From the simulation results shows that the bit error rate (BER) and mean square error rate is improved for 2×2 antennas.

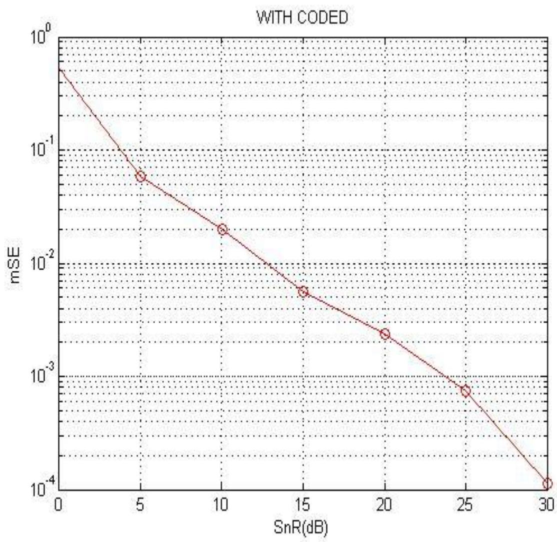


**Figure 4**: Graph plot between SNR and MSE using 2 transmit antenna and 2 receive antenna with AWGN channel

## 6. Conclusion

In this paper, new pilot sequence insertion method for MIMO-OFDM system with two transmits and two receiving antenna is studied with AWGN channel. In this method there is no extra OFDM symbol are required and thus it is better than that of the conventional pilot sequence method. To estimate the channel state information the pilot symbols are inserted with iteration method so that the complexity of the system is reduced. The bit error rate (BER) and mean square error is reduced by using this method.

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