Channel Estimation in MIMO-OFDM System using LS, LMMSE and STBC Technique

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***Abstract*— In this paper, various channel estimation method has been investigated for MIMO-OFDM based system. Multiple input, multiple output (MIMO) is a suitable technique which can gives a high transmission data rate without dominating the transmission power for wireless communication system. The combination of multiple input, multiple output (MIMO) with orthogonal frequency division multiplexing (OFDM) provides excellent data rate transmission beyond the broadband wireless channel. In multiple input multiple output orthogonal frequency division multiplexing (MIMO-OFDM) system, the channel state information is very convenient. So channel state information sometime censorious the efficacy of the system and the correct signal cannot received properly at the receiver side. The system performance has been amended by examine the channel at the receiver side properly. The training symbol sends along the data symbol to estimate the channel in the system. In OFDM the cyclic prefix is used at the starting of every transmitted OFDM symbol to reduces the inter carrier interference (ICI) and inter symbol interference (ISI). There is another improved pilot pattern algorithm is used to aid the channel estimation and provide good performance of the system. Space time block code (STBC) is a method though which the channel estimation can be done more effectively in MIMO-OFDM system. In space time code data is encoded and then data is discarding into n- number of spurt and then this data is send by a number of transmitted antennas. In STBC n-number of transmitted and receiving antenna can be used and it provides a good performance in multipath fading channels.**

Keywords— Lleast square, LMMSE, STBC, OFDM.

I. INTRODUCTION

In modern era, there is a high speed of data is required to fulfill the demand of users in the wireless communication system. A huge speed of data is demanded in the modern technology [1]. Due to increases the demand of multimedia services and internet services, a very high data is required through which the communication become faster. There are many methods to achieve a good and steep data. To attain a huge system capacity in wireless communication many new advanced methods has been developed [2]. Multiple input multiple output (MIMO) has been contemplated 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 [3]. In multiple inputs multiple output system there is no additional bandwidth is required. The data can be send through many path called multipath and thus fading occur. In order to reduce the effect of frequency selective fading, orthogonal frequency division multiplexing (OFDM) with multiple input multiple output (MIMO) has been proposed. Orthogonal frequency division multiplexing (OFDM) plays an important role in wireless communication system because frequency selective and time variant is mostly used in radio channel for mobile communication [4]. 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 brawn against frequency selective fading channels and it can converts these channels into number of small flat subcarriers and deflects multipath fading [5]. There is cyclic prefix is added at the starting of every OFDM symbol to reduces the effect of inter symbol interferences and plays a role in fourth generation communication system. The amalgamate of MIMO-OFDM system used in the modern wireless communication system and thus they can be used in WiMAX, 3GPP LTE and IEEE 802.11n [6]. The combination of MIM0-OFDM system can increases the data rate and hence the multipath fading has been decreased. The combination of MIMO-OFDM system enlarge the system capacity by using the transmission diversity technique [7]. In MIMO-OFDM system the efficacy is depends upon the channel estimation and it is difficult task to estimate the channel state information [8]. The channel estimation in MIMO-OFDM is very applicable because at the receiver side there is a multiple users interferences can be occur so in order to eliminate these interferences channel estimation is required [9]. The channel estimation can be done by the proper knowledge of channel at the receiver side [10]. Mostly the channel can be estimated by providing the pilot symbols along with the transmitting signal which is known by the receiver [11]. There is various methods to transmit the pilot symbols along the transmitting data. The pilot symbols are of two types; block type pilot symbols and comb type pilot symbols [12]. In block type pilot the symbols are send periodically along each OFDM symbol and it can be used for slow fading. The pilots are inserted into all of the subcarriers of one OFDM symbol with a certain period of time. In comb type pilot the symbols are inserted over all sub channels in each OFDM symbols. In this method channel estimation can be based on least square and minimum mean square error. In Comb type interpolation must be used in order to reduce the channel response over the whole bandwidth. Space time block coding is a newly proposed method used to combines the signal at the receiver side with multiple antenna using coding

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techniques and provide an eloquent gain and good efficiency in MIMO-OFDM system [13]. 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 [14]. In space time coding there is no interpolation method is used. Space time coding uses new encoding and decoding algorithms which is less complex than other algorithms.

The rest of the paper addresses: section 2nd contains MIMO-OFDM. Section 3rd contains block type and comb type coding. Section 4th contains LS and MMSE method for channel estimation. Section 5th contains STBC method with encoding and decoding. Section 6th contains simulation and results.

II. SYSTEM DESCRIPTION IN MIMO-OFDM SYSTEMS

MIMO-OFDM system plays an important role in the fourth generation of communication system so that it can increase the data rate and the system capacity and removing the multiple paths fading. The block diagram of MIMO-OFDM consist of T_x transmit antenna, R_x received antenna and N is the number of subcarriers.

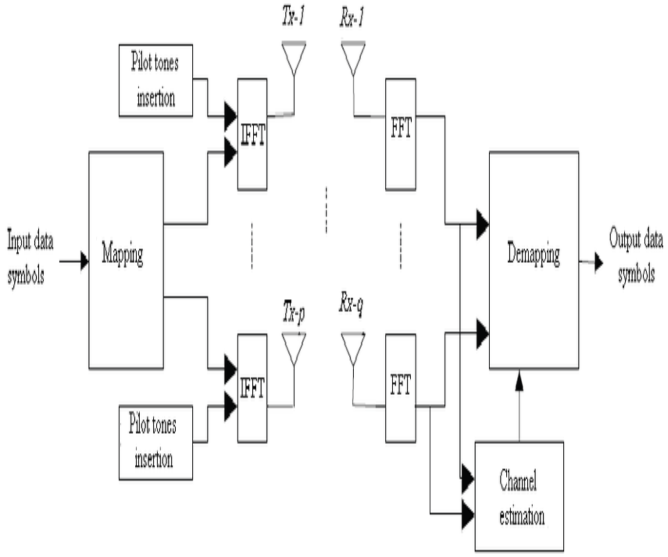

Fig. 1: MIMO-OFDM System

The input signals get modulated with the various modulation schemes such as 16 QAM, QPSK and PSK etc. The impulse response in time domain between the transmission i^{th} antenna and the j^{th} antenna is given by;

$$h_{i,j}(t,\tau) = \sum a_{pn}\delta(\tau - \tau_{pn})$$

K = Total path number to the maximal time delay, P = Path number, a_p = Path gain for the p^{th} path at the moment τ = Time delay, τ_{pn} = Time delay of p^{th} path

The path gains a_{pn} is considered to be not dependent upon the wide sense stationary narrow band complex Gaussian processes.

As a result the frequency response at time t is;

$$H(t,f) = \int_{-\infty}^{\infty} h_{i,j}(t,\tau) e^{-2\pi f \tau_{pn}} = \sum_{pn} a_{pn}(t) e^{-2\pi f \tau_{pn}}$$

Now consider the N subcarrier and then the sampling becomes

$$H[n,K] = H[nT_s, K\Delta f]$$

$$= \sum_{l=0}^{Nl} h[n,l] W_K^{Nl}$$

Where h (n, l) = h (nT_s, t_s), $W_K = \exp(-j2\pi/K)$, M = number of sample spaced channel, K = number of subcarriers, T_s = OFDM symbols length.

Now in the OFDM the symbols that can be transmitted over the frequency selective fading MIMO channels are independent on each other. Now there is a M number of taps. Let us assume that there is only one transmitting antenna and only one receiving antenna so it can be written as;

$$Y_V = X_V H_V + C_V$$

The cyclic prefix is removed at the receiver side and discrete Fourier transform can be applied to achieve the correct data.

III. CHANNEL ESTIMATION IN MIMO-OFDM SYSTEM

Channel state information is an important part in the channel estimation. The channel can be estimated only if there is a proper knowledge of information is given in the channel. So the training pilots are sent with the OFDM symbols with the certain interval of time. Block type and Comb type pilots are used for channel estimation in MIMO-OFDM system.

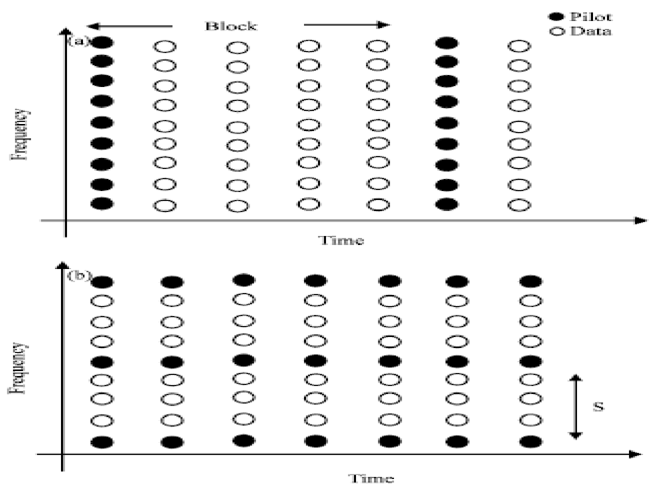

Fig. 2: Block type and Comb type pilot for channel estimation

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A. Least Square Alogrithm At Pilot Subcarriers

The main idea behind the least square error estimator is reduces the distances. The LSE can be written as:

$$H_{LS} = (X)^{-1}\, Y$$

Where, H_{LS} represents the least square estimation.

B. Linear Minimum Mean Square Error

The LMMSE also used to reduces the estimator error and it can be written as;

$$H_{LMMSE} = Rhh_u\,(Rh_uh_u+\sigma^2_\mu\,(XX)\,H_{LS}$$

Rhh_u = the cross correlation matrix between the references subcarrier signal and all subcarrier, Rh_uh_u = Autocorrelation matrix of the subcarriers with the signal

The LMMSE estimation equation becomes;

$$H_{LMMSE} = Rhh_u\,(Rh_uh_u+\beta/SNR\ I)^{-1}$$

SNR = signal to noise ratio, I = identity matrix, β = scaling factor.

C. Stbc Algorithm:

The improved algorithm is proposed by almost to reduce the complexity in channel estimation method. Space time block coding is a method through which the channel estimation is done easier. Channel estimation is a technique through which the signal propagation through various paths can be determined. In the STBC, there are two OFDM frames can be involved such as signal can be divided into two parts. Let us take a four symbols and the STBC can be written as;

$$G_4 = \begin{bmatrix} T_1 & T_2 & T_3 & T_4 \\ -T_2 & T_1 & -T_4 & T_3 \\ -T_3 & T_4 & -T_1 & T_2 \\ -T_4 & -T_3 & T_2 & T_1 \\ T_1^* & T_2^* & T_3^* & T_4^* \\ -T_2^* & T_1^* & -T_4^* & T_3^* \\ -T_3^* & T_4^* & -T_1^* & T_2^* \\ -T_4^* & T_3^* & T_2^* & T_1^* \end{bmatrix}$$

At the transmitter, the signal can be generated and using the various modulation schemes such as QAM, QPSK and BPSK the signal can be modulated. The signal can be encoded at the transmitter side and decoded at receiver side. The signal fed to STBC encoder and then signal can be transformed into parallel sequences. The pilot signal cab ne generated and then this signal goes to inverse fast Fourier transformation block (IFFT). The output of IFFT can be expressed as

$$x^{\alpha}_{t,n} = \sum_{k=0}^{N-1} X^{\alpha}_{t,k}\, e^{j2\pi Kn/N}$$

Where α is transmitting antenna and α = 1,2… n and K = 0,1,2… After that CP is inserted and then the signal impulse response become;

$$r_{j,t,n} = \sum_{l=0}^{L-1} h^{\alpha}_{j,t,l}\, x^{\alpha}_{t,n-l} + w_{j,t,n}$$

Where $h^{\alpha}_{j,t,l}$ = channel impulse response. At the receiver side the signal can be reached and cyclic prefix is removed so the output become;

$$R_{j,t,n} = \sum_{l=0}^{N_t} H^{\alpha}_{j,t,k}\, X^{\alpha}_{t,k} + w_{j,t,k}$$

Where

$$H^{\alpha}_{j,t,k} = \sum_{k=0}^{N-1} h^{\alpha}_{j,t,l}\, e^{-2\pi kn/N}$$

Here j = 1, 2… n and α = 1, 2. $W_{j,t,k}$ = white Gaussian noise with zero mean and unity variance. N_t and N_r represents the quantity of transmit and receive antenna. Now the signal can be decoded by space time block coding and channel can be modeled as IIR with L+1 non- zero path with mean zero and σ_1^2 with average power.

IV. SIMULATION AND RESULTS

After A combination of two transmitters and receiver antennas has been used respectively considering Rayleigh fading having 64 subcarriers and BPSK modulation technique. In this the data is encoded with the space time block coding. The simulation results are drawn between the signal to noise ratio and bit error rate ratio showing the better results than that of the LS and LMMSE algorithm.

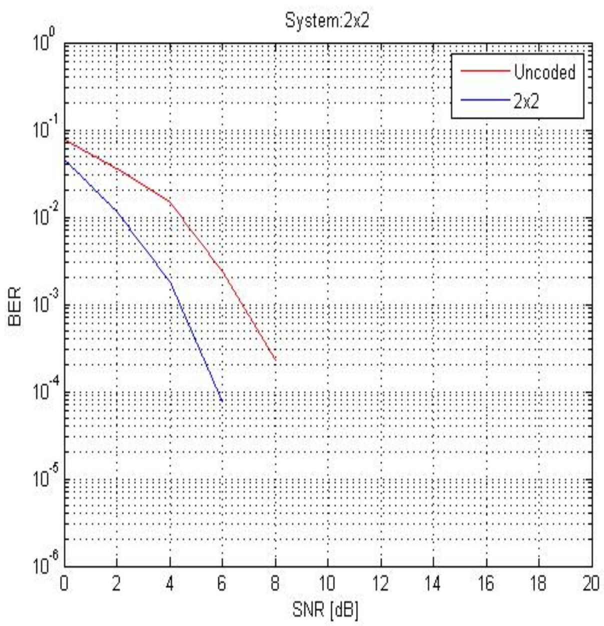

Fig 3: BER vs. SNR BPSK for SNR 20

V. CONCLUSION

In this paper the channel estimation has been done by various techniques. The block type and comb type pilot insertion method also investigated for various fading channels. In comb type pilot arrangement the heterogeneous interpolation method is used and hence complexity is

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increases. Space time block coding (STBC) is used to reduce the complexity. In STBC no interpolation is used and it has lower complexity than LMMSE and LS method. So from the above discussion it is proved that STBC algorithm is best for the channel estimation in multipath fading channels.

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