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Channel Estimation With TAS in MIMO OFDM Systems

Ann Mary Soney
PG Scholar, Communication Engineering
Amal Jyothi College of Engineering
Kanjirappally, India

Binu Mathew
Assistant Professor
Amal Jyothi College of Engineering
Kanjirappally, India

***Abstract*—In the proposed scheme channel estimation with Transmitter Antenna Selection (TAS) in Space Frequency Block Coded (SFBC) Multiple Input Multiple Output (MIMO) Orthogonal Frequency Division Multiplexing (OFDM) is done. Channel estimation is carried out using simple Least Square (LS) estimator using pilots in frequency domain. After getting proper channel knowledge, antenna selection is done. Selection criterion is based on the Highest Norm Approach (HNA). The performance of the proposed MIMO OFDM system with TAS is analyzed based on the bit error rate (BER) curve.**

Keywords—Channel Estimation, MIMO OFDM, TAS, HNA.

I. INTRODUCTION

During the last few decades, there has been an increasing emphasis on bandwidth hungry applications. Since the amount of information transmitted over the communication systems are growing rapidly there was a need for high data rate services. Over broad band wireless channels, high data rate can be achieved using multiple-input multiple-output (MIMO) communication system combined with the orthogonal frequency division multiplexing (OFDM) modulation technique [1]. OFDM is a multiplexing and multicarrier modulation techniques that divides high data rate stream into parallel lower data rate stream thus it avoids inter symbol interference (ISI) that occur in channel due to fading. For improving the air interface performance for Wireless Metropolitan Area Networks (WMAN), MIMO-OFDM presents an exciting solution [2]. Wireless communication system's performance is governed by the channel environment. So it is required to estimate the channel in order to remove the effects of fading [3]. Channel estimation in MIMO OFDM systems can be done using blind, semi blind or training based method.

In case training based channel estimation usually block type or comb type arrangement are employed. The channel estimation methods for OFDM systems based on comb-type pilot sub-carrier arrangement are investigated in [4]. Pilot arrangement can be done in time domain and frequency domain. In case of block type arrangement is done in time while for comb type it is done in frequency domain. Comb type arrangement contains pilots in some subcarriers only, therefore the channel response of non-pilot subcarriers will be estimated by interpolating neighboring pilot sub-channels [5]-[6] . Another type of pilot arrangement is employed in [7] which convert the complexity of multiple antenna channel estimation into simple single antenna system where the channel estimation process can be completed with only one OFDM symbol. Therefore channel estimation using such a pilot subcarriers arranged in frequency domain is used for MIMO OFDM system investigated in this paper.

Antenna diversity is a very practical, effective and, hence, a widely applied technique for reducing the effect of multipath fading. Transmit diversity schemes are very attractive. It is therefore more economical to add equipment to base stations rather than the remote units [8]. Transmit diversity can be achieved by using Space time block coding (STBC) or Space frequency block coding (SFBC). SFBC coding is employed here provides better resistance against frequency selective fading while antenna selection improves the quality of received signal. Antenna selection with SFBC coding in MIMO OFDM system is employed in [9]. In a wireless communication system channel state information is unknown. The proposed method estimates the channel and selects the transmitter antenna. Selection is based on Highest Norm Approach (HNA).

The rest of the paper is arranged as follows: section II describes about the channel estimation. A brief explanation of antenna selection is given in section III, section IV describes about proposed system. Finally simulation results are shown in section V.

II. CHANNEL ESTIMATION IN MIMO OFDM SYSTEM

Channel estimation is done in order to recover the transmitted signal. In this paper estimation is done using least Square (LS) estimator with an orthogonal pilot pattern. First the estimation is done for 2X2 MIMO OFDM. Then estimation is extended for 4X4 and 8X8 systems. Since we are having larger number of antennas and LS is less complex, the estimator used here is LS. Pilot pattern is used here for estimating channel which converts the complex M_R X M_T system, (where M_T denotes total number of transmitters and M_R denotes total number of receivers) into simple Single Input Single Output (SISO) pattern. The pattern used is pilot scheme [7] shown in Fig. 1. Since the antenna number increases for selection, pilot scheme used in 2x2 systems is extended for higher number of antennas as shown in Fig .2.

The pattern in Fig.1 is used for 2X2, similarly pattern is extended for 4X4 and then for 8X8 system. The arrangement of pilots is in such a way that when pilot signals are transmitted other all antennae remain silent. Since pilots are arranged in frequency domain first LS is done to estimate Channel Frequency Response (CFR) in pilot position then it is interpolated to find the channel response in other positions. At receiver, signal y(n) will be convolution of channel h(n) and transmitted signal x(n) with noise addition w(n) (1).

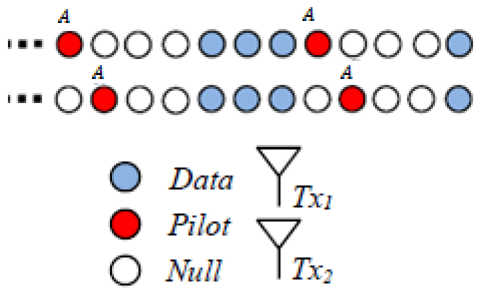

Fig. 1. Pilot pattern for 2x2 system

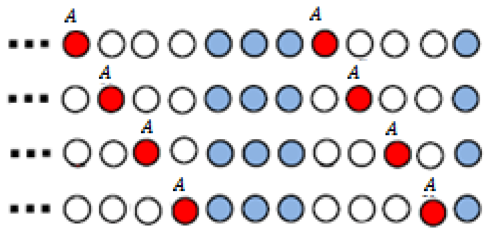

Fig. 2. Pilot pattern for 4x4 system

$$y(n) = x(n) * h(n) + w(n), \quad n = 0,1 \ldots . L-1 \qquad (1)$$

The frequency domain representation of (1) is

$$Y(K) = X(K)H(K) + N(K) \qquad (2)$$

$$H(K) = Y(K)/A(K) \qquad (3)$$

Y(K) is the received signal, X(K) contains transmitted signal and H(K) is the CFR at that position. N(K) is Additive White Gaussian Noise (AWGN) and A(K) denotes pilots transmitted. Using (2) and (3) LS is done and then response at other subcarriers are obtained by using interpolation. After getting interpolated values of H in all positions data can be retrieved using (4) where H^H denotes Hermitian and H^+ denotes pseudo inverse. The SNR vs. BER plot is shown in Fig. 5. After getting all estimates of channel, antenna selection is done.

$$X = (H^H H)^{-1} H = H^+ Y \qquad (4)$$

III. ANTENNA SELECTION

For an M_R X M_T antenna system we can have the channel matrix H(k) for k^{th} sub channel (5) can be written as

$$H[k] = \begin{bmatrix} H_{1,1}[k] & \cdots & H_{1,M_T}[k] \\ \vdots & \ddots & \vdots \\ H_{M_R,1}[k] & \cdots & H_{M_R,M_T}[k] \end{bmatrix} \qquad (5)$$

BER performance of system depends on SNR, while SNR depends on Frobenius norm of sub channel. In case of antenna selection we use N_T out of M_T and N_R out of M_R antennas. In TAS with HNA we select N_T columns having highest norm which is similar to select transmitter antenna [9]. Here we select two antennas having highest norm. The received SNR of k^{th} sub channel can be shown as

$$SNR_k = \left(\frac{\Gamma_e}{N_T R_c}\right) \sum_{i=1}^{M_R} \sum_{j=1}^{N_R} \left|H_{i,j}[k]\right|^2 \qquad (6)$$

$\Gamma_e = E_b/N$, E_b denotes the symbol energy; R_c denotes the coding rate of SFBC 2X1 system [9]. As we select N_T =2 out of M_T antennas the average gain in SNR (6) can be written as

$$G = \left(\frac{1}{2M_R}\right) E\left\{\sum_{i=1}^{M_R}\left(\left|H_{i,1}[k]\right|^2 + \left|H_{i,2}[k]\right|^2\right)\right\} \qquad (7)$$

IV. PROPOSED SYSTEM

The block diagram shown in Fig .3 gives channel estimation for M_R X M_T system. Antenna selection using SFBC coding with HNA block is shown in Fig.4. SFBC coding provides space and frequency diversity when used with MIMO OFDM system. Even though both SFBC and STBC provide orthogonality, SFBC coding is more reliable in frequency selective fading channel. Let X is output of the modulation block in Fig. 4. Then X in (8) is SFBC coded using (9), and then fourier transform is taken thereafter cyclic Prefix (CP) added and transmitted.

$$X = [X[0], X[1] \ldots X[L-1]]^T \qquad (8)$$

$$B = \begin{bmatrix} X(2m) & X(2m+1) \\ -X(2m+1)^* & X(2m)^* \end{bmatrix},$$
$$m = 0,1, \ldots . \left(\frac{L}{2}\right) - 1 \qquad (9)$$

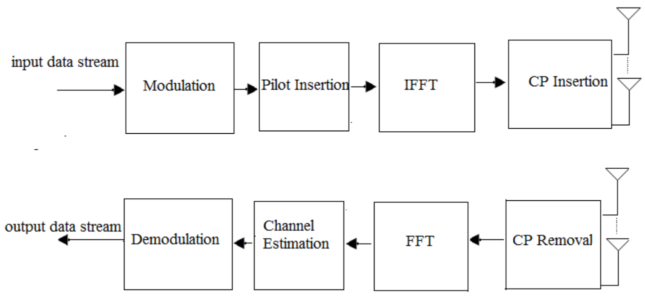

Fig. 3. Channel estimation for M_R X M_T system

For proper implementation of SFBC the channel is assumed to be quasi static for two neighbouring subcarriers (10). After receiving the signal, HNA approach is used for selecting the best channel which is done by choosing subchannels having highest norm and is substituted in (11). Since here we use N_T=2, we have only two transmitted signal at an antenna. The signal can be decoded with maximum likelihood detector using (11) since channel is known, where r_i denotes the received signal from i^{th} receiver, $\breve{X}[2k]$, $\breve{X}[2k+1]$ are decoded signal [9]. With the help of HNA the transmitted antenna is selected.

$$H_{i,m}[2k] = H_{i,m}[2k+1] \quad (10)$$

$$H_{i,n}[2k] = H_{i,n}[2k+1]$$

$$\breve{X}[2k] = \sum_{i=1}^{N_R} H^*_{i,m}(2k) r_i(2k) + H_{i,n}(2k) r^*_i(2k+1) \quad (11)$$

$$\breve{X}[2k+1] = \sum_{i=1}^{N_R} H^*_{i,n}(2k+1) r_i(2k) - H_{i,m}(2k+1) r^*_i(2k+1),$$

$$k = 0,1,\ldots\frac{L}{2}-1$$

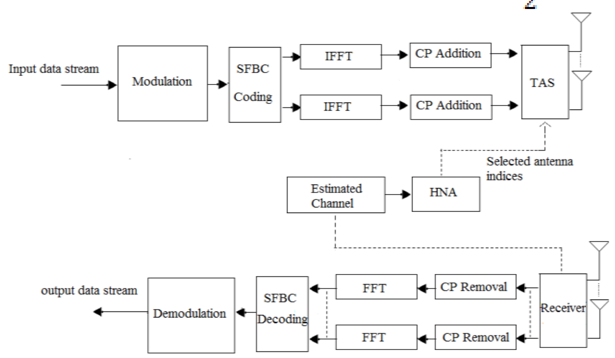

Fig. 4. Proposed system for transmitter antenna selection with highest norm approach.

V. SIMULATON RESULTS

The performance analysis of the proposed system can be analyzed with SNR vs. BER curve. Simulations were performed in MATLAB. Channel estimation is done with the help of LS using the pilot pattern for 8X8 system and BER curve is plotted as shown in Fig.5. From Table 1 we can conclude that a proper estimate of channels have done as SNR increases BER decreases.

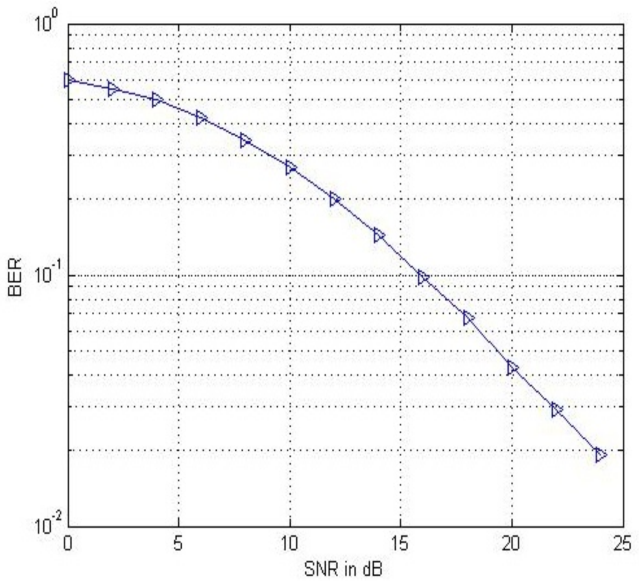

Fig. 5. SNR curve for channel estimation in 8x8 system

$$BER_k = \left(\frac{2}{\omega}\right)\left(1 - \left(\frac{1}{\sqrt{2^{\omega}}}\right)\right)$$

$$\times\, erfc\left\{\sqrt{\frac{1.5r_s}{2(2^{\omega}-1)}\sum_{i=1}^{M_R}\left(\left|H_{i,1}[k]\right|^2 + \left|H_{i,2}[k]\right|^2\right)}\right\} \quad (12)$$

TABLE I. BER VARIATION WITH SNR FOR CHANNEL ESTIMATION USING 8X8 SYSTEM

SNR in dB	BER
0	0.594271
2	0.552792
4	0.485417
6	0.423396
8	0.346958
10	0.273021
12	0.200396
14	0.144604
16	0.103021

In Fig.6 for TAS with HNA we use total transmitter (M_T=8), total receiver (M_R=1), Code rate (R_c =1). Theoretical curves are obtained using (12), where $\omega = log_2 M$, M=4 for 4 QAM (Quadrature Amplitude Modulation), $H_{i,1}[k]$, $H_{i,2}[k]$ are selected sub channels [9]. Number of transmitter antenna selected at a time is (N_T =2) and receiver (N_R =1). It can be seen from Table II that, for SNR of 8 dB, the system selecting 2 out of 8 transmit antennae have a BER of 0.0075 while system selecting 2 out of 4 have 0.0541 for same SNR. Therefore selecting 2 from 8 have lesser BER than 2 from 4. The other two curves show the case of no selection, one for 2X1 and other for SISO system.

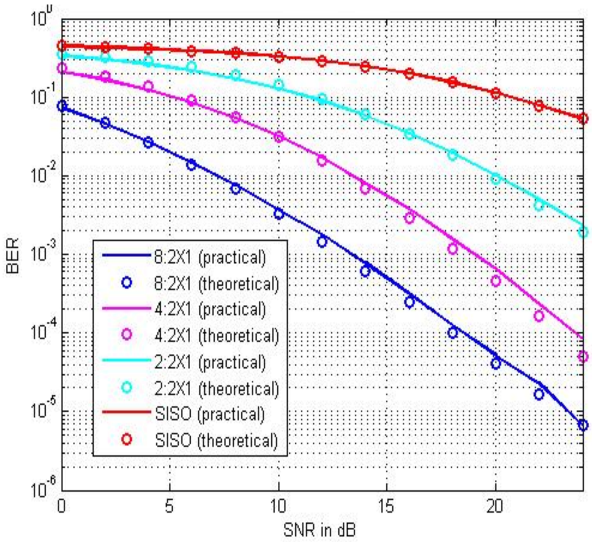

Fig. 6. SNR curve for antenna seletion

TABLE II. BER VARIATION WITH SNR FOR ANTENNA SELECTION

	Bit Error Rate			
SNR in dB	**2X1 out of 8X1**		**2X1 out of 4 X1**	
	Theoretical	**Practical**	**Theoretical**	**Practical**
0	0.0782	0.0736	0.2340	0.2102
2	0.0472	0.0456	0.1847	0.1662
4	0.0264	0.0269	0.1355	0.1230
6	0.0138	0.0147	0.0912	0.0849
8	0.0068	0.0075	0.0557	0.0541
10	0.0032	0.0037	0.0308	0.0318
12	0.0014	0.0018	0.0153	0.0172
14	0.0006	0.0008	0.0070	0.0081
16	0.0003	0.0003	0.0030	0.0037

CONCLUSION

Channel estimation with TAS using HNA approach is proposed in this paper. Usually when TAS is done channel is assumed to be known here we are able to estimate the channel using orthogonal pilot pattern which reduces the complexity of higher order systems. The use of HNA helps to select two channels having highest norm. Simulation results shows that for an SNR of 8 dB the system selecting 2 out of 8 transmit antennae have a BER of 0. 0075 while system selecting 2 out of 4 have 0.0541 for same SNR. Thus selecting antenna from higher number of transmitter provides better BER performance.

REFERENCES

[1] Kala Praveen Bagadi, Prof. Susmita Das, “MIMO-OFDM Channel Estimation using Pilot Carries,” International Journel of Computer Application *(*0975 – 8887) Volume 2 – No.3, May 2010.

[2] Hermann Lipfert “MIMO OFDM Space Time Coding – Spatial Multiplexing Increasing Performance and Spectral Efficiency in Wireless Systems,” Broadcast Networks and Servers

[3] Yong Soo Cho, Jaekwon Kim, Won Young Yang and Chung G. Kang, “MIMO-OFDM Wireless Communications with Matlab,” John Wiley & Sons Pvt. Ltd, Asia, 2010.

[4] Meng-Han Hsieh and Che-Ho We, “Channel Estimation for OFDM Systems Based on Comb-Type Pilot Arrangement in Frequency Selective Fading Channels,” IEEE Transactions on Consumer Electronics, Vol. 44, No. 1, February 1998.

[5] E Tufvesson and T Maseng, “Pilot assisted channel estimation for OFDM in mobile cellular systems,” in P roc. IEEE 47th Vehicular Technology Conference, Phoenix, USA, May 1997, pp. 1639-1643

[6] J. Rinne and M. Renfors, “Pilot spacing in orthogonal frequency division multiplexing systems on practical channels,” IEEE Trans. Consumer Electronics, vol. 42, no. 4, Nov. 1996.

[7] N. Promsuwanna, P. Uthansakul and M. Uthansakul, “A Novel Pilot Scheme for Frequency Offset and Channel Estimation in 2x2 MIMO-OFDM,” World Academy of Science, Engineering and Technology, International Science Index Vol.7, No.2, 2013 waset.org/Publication/2277.

[8] Siavash M. Alamouti, “A Simple Transmit Diversity Technique for Wireless Communications,” IEEE Journal On Select Areas In Communications, Vol. 16, No. 8, October 1998

[9] Mohammad Torabi, “Antenna selection for MIMO-OFDM systems,” Signal Processing, vol. 88, 2008, pp. 2431-2441.