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A Novel Approach for Channel Estimation In MIMO-OFDM System Using The Efficient Pilot Patterns

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Abstract

A novel approach is presented in this work to efficient pilot patterns estimation as well as channel estimation in multiple input-multiple output orthogonal frequency division multiplexing system. In our proposed work, we exploit the basic orthogonal property of unitary matrix based on scattered pilot, continuous pilot and edge pilot in order to estimate the pilot patterns in accurate manner. Efficient channel frequency response and channel impulse response estimation is done in our proposed work by orthogonal property analysis. Finally, the proposed work simulation results evaluation yields high end performance when compare to the conventional works such as multi input-single output OFDM system.

INTRODUCTION

High data rate multimedia services are gaining importance in the field of wireless broadcasting systems such as 3D HD television and ultra HD television. As technology is changing its face day by day to provide mankind sophisticated and comfortable life, high equipped data rate services are providing such a experience in application like HD television. Recently so many advance broadcasting systems like multiple input-single output system (MISO) which has multiple transmit antennas and single receive antenna, multiple input-multiple output system (MIMO) which has multiple transmit antennas and multiple receive antennas are proposed in the conventional works. When compared to the multiple input-single output system (MISO) the multiple input-multiple output system (MIMO) yields good performance because MIMO-OFDM mitigates the inter symbol interference(ISI) affected by frequency-selective fading as well as a significant time/frequency diversity gain.

BACKGROUND

Future terrestrial broadcasting system is expected to support the high data rate multimedia and high quality devices. The main aim is to design different pilot patterns and channel estimations for the multiple input-multiple output system multiple input-single output system (MIMO) system. A distributed SFC processing for use in (MISO-

OFDM) system of the 2nd generation terrestrial digital video broadcasting is taken as reference. Two independent SFCs for two sets of two transmit antennas are considered as shown in Fig. 1. The associated issues are summarized as follows

1) Exploiting an orthogonal property found in the pilot patterns of DVB-T2 system, we design the efficient scattered pilot (SP), edge pilot (EP), and continuous pilot (CP) patterns

2) From the acquired orthogonal property and pilot patterns, it is also presented that the estimations of channel frequency response (CFR) and channel impulse response (CIR) can be efficiently performed. Finally, we numerically assist the mean-square error (MSE) and symbol-error rate (SER) performances of the proposed MIMO-OFDM system by comparing those of the MISO-OFDM system of DVB-T2 over Hilly-Terrain (HT) channel. **DECRIPTION ANALYSIS OF MIMO-OFDM SYSTEM**

Multiple input-multiple output system (MIMO) is mainly comprises of two sections as illustrated below

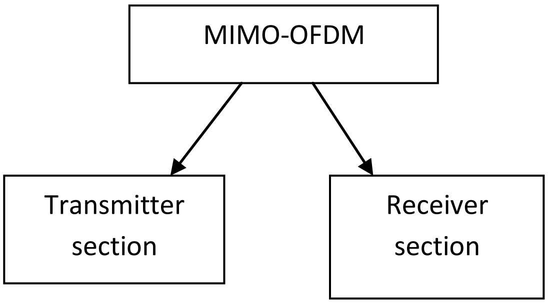

Figure 1 MIMO-OFDM

Transmitter section:

In MIMO-OFDM transmission of information from one end to another end is done by transmitter. In MIMO mechanism there are multiple transmitters to transmit more information at a time. Our proposed work has multiple transmitters (N_T=4) as depicted in Figure 1.In Figure 1 we have nth output bocks {S_i (n, s): n=1, 2, 3……, s=0, 1….N-1} of a symbol generation for i=1, 2, where s and N_s denote the symbol index and block length, respectively. A pair of symbols in each block is first encoded according to a SFC C_i rule

$$C_i = \begin{bmatrix} s_i(n,s) & s_i(n,s+1) \\ S_i^*(n,s+1) & S_i^*(n,s) \end{bmatrix}$$

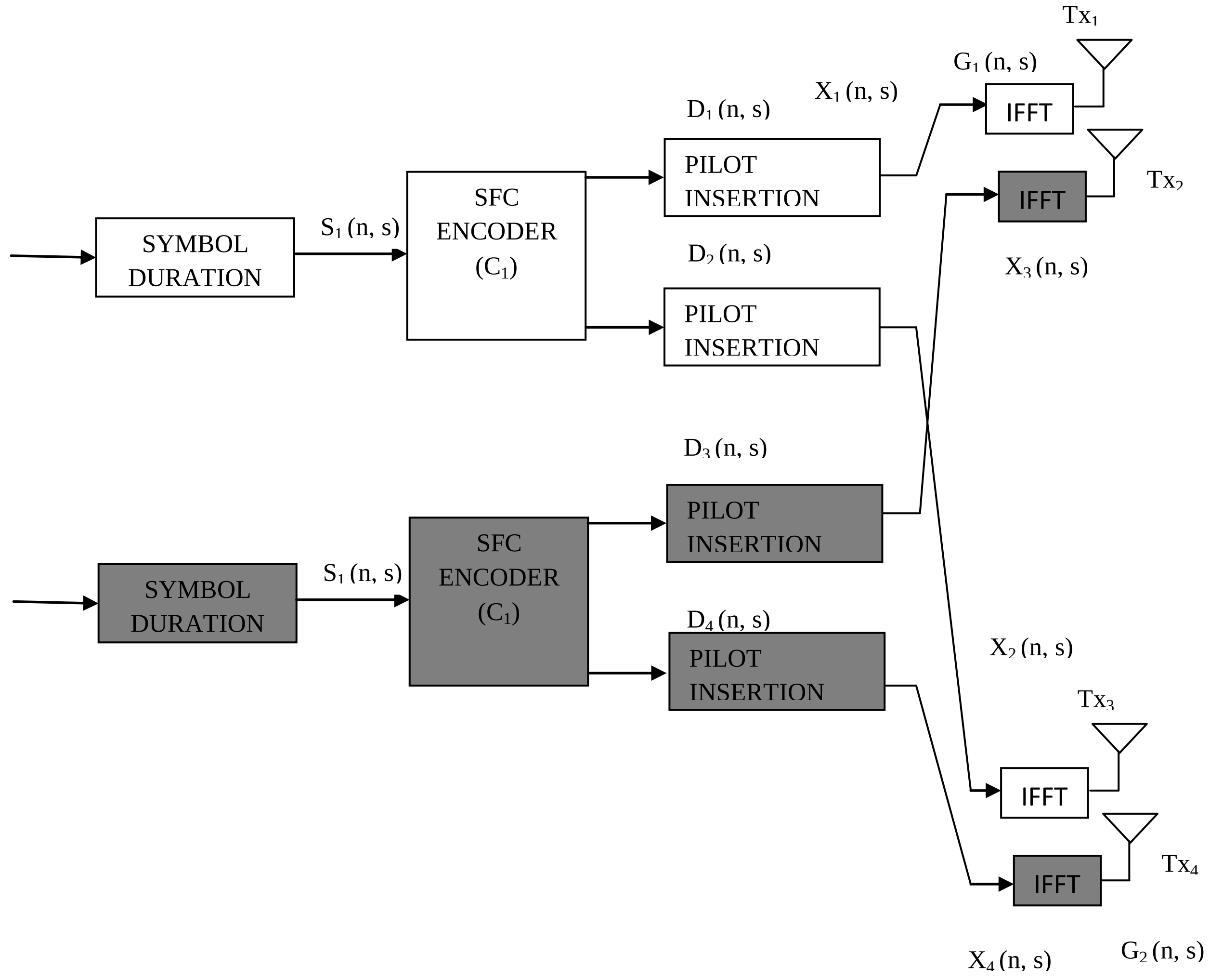

Figure 1 MIMO-OFDM transmission with two independent SFCs

The above equation comprises of parameters which denotes the complex conjugate operation $(.)^*$. The nth output blocks are defined as $\{D_t$ (n, s): t=2(i-1) +d, s=1, 1, N_s-1, d=1,2$\}$ for i=1,2. Therefore D_t (n, s)(for t=1,……4) are multiplied with various pilot sub carriers. At this time the input of the IFFT of size N_1 are defined as $\{X_t$ (n, k) : k=K_{min},…. $K_{max}\}$ Where k denotes a sub carrier index K_{min} and K_{max} denote the minimum and maximum sub carrier indexes, respectively. Then, finally nth OFDM blocks are efficiently grouped as shown in Figure 1, i.e., G_1 (n, s) = $[X_1$ (n, s), X_3(n, s)$]^T$ and G_2 (n, s) = $[X_2$ (n, s), X_4(n, s)$]^T$ and where$(.)^T$ denote the transpose operator. Then after successfully grouping the OFDM blocks, OFDM blocks are transmitted after a guard interval is placed with size N_G

Receiver Section

At the receiver section we consider multiple antennas (N_R=2) because we are using the MIMO approach so to receive the data from the multiple transmitters we use the multiple receivers at the receiver end. In receiver section, in order to obtain the data inserted in the sub carriers first we should successfully remove the Guard interval and FFT from the system which is inserted at the transmitter section for interference free transmission. The received signal vector is as shown in equation 2

$$Y(n,k) = H_1(n,k)G_1(n,k) + H_2(n,k)G_2(n,k) + W(n,k),\ for\ k = 0, \ldots\ldots . N_I - 1$$

Where $W(n, k) = [W_1(n, k), W_2(n, k)]^T$, and in receiver section we made an assumption for $W_j(n, k)$ has zero mean with variance of $\sigma_w^2[k]$ and uncorrelated for different parameters n, k, and j. The nth channel frequency response (CFR) in equation 2 is defined as

$$H_i(n,k) = \begin{bmatrix} H_{1,2i-1}(n,k) & H_{1,2i}(n,k) \\ H_{2,2i-1}(n,k) & H_{2,2i}(n,k) \end{bmatrix}$$

Where $H_{j,t}(n,k)$ denotes the channel frequency response between the t_{th} transmit and j_{th} receive antennas experienced by the K_{th} subcarrier

PROPOSED PILOT PATTERNS

The proposed literature work proposes the novel pilot patters namely scattered pilot, continuous pilot and edge pilot in order to estimate the pilot patterns in accurate manner. By using these novel pilot patterns we process the extended or normal carrier mode operation in multiple input-single output system (MISO) approach. By using the unitary matrix we exploit the total pilot structure as follows

$$P_4 = \begin{pmatrix} 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & -1 \\ 1 & 1 & -1 & -1 \\ 1 & -1 & -1 & 1 \end{pmatrix} = \begin{pmatrix} P_2 & P_2 \\ P_2 & -P_2 \end{pmatrix}$$

From the above structure it reveals that the total pilot structure is built by basic pilot patterns P_2. Hence it is noticed that P_4 can be expressed by using the basic pilot patterns P_2.

The pilot patterns proposed in this work as categorized into three categories namely

A. Scattered Pilot pattern
B. Continuous Pilot pattern
C. Edge Pilot pattern

A) Scattered Pilot

The name itself reveals that scattered pilots are intended to design to know the scattered pilot vector symbols by using the parameters N_p, P, X_t respectively. The location of scattered pilot vector symbols pattern P is localized by using the X_t and its respective operation is shown following equation

$$P_1^s(n,p) = \begin{cases} +P_1^s(n,p), mod(n,\Delta T) = 0 \\ +P_1^s(n,p), mod(n,\Delta T) = 1 \\ +P_1^s(n,p), mod(n,\Delta T) = 2 \\ +P_1^s(n,p), mod(n,\Delta T) = 3 \end{cases}$$

$$P_2^s(n,p) = \begin{cases} +P_1^s(n,p), mod(n,\Delta T) = 0 \\ -P_1^s(n,p), mod(n,\Delta T) = 1 \\ -P_1^s(n,p), mod(n,\Delta T) = 2 \\ +P_1^s(n,p), mod(n,\Delta T) = 3 \end{cases}$$

$$P_3^s(n,p) = \begin{cases} +P_1^s(n,p), mod(n,\Delta T) = 0 \\ -P_1^s(n,p), mod(n,\Delta T) = 1 \\ +P_1^s(n,p), mod(n,\Delta T) = 2 \\ -P_1^s(n,p), mod(n,\Delta T) = 3 \end{cases}$$

$$P_4^s(n,p) = \begin{cases} +P_1^s(n,p), mod(n,\Delta T) = 0 \\ +P_1^s(n,p), mod(n,\Delta T) = 1 \\ -P_1^s(n,p), mod(n,\Delta T) = 2 \\ -P_1^s(n,p), mod(n,\Delta T) = 3 \end{cases}$$

B) Edge Pilot

The Edge pilots are usually inserted in order to allow a frequency-interpolation (FI) up to the edge of the spectrum. In DVB-T2 system, the basic composition of EP pattern exactly follows to the SP pattern except that the EPs are only inserted in every OFDM symbol and similarly the composition of Edge patterns follows.

C) Continuous Pilot

In general, the CP is inserted for use in a synchronization associated with the timing acquisition and tracking. In addition to the SP, a number of CPs is inserted in every OFDM block. In DVB-T2 system, the number and location of CPs depend on both the FFT size and the used SP pattern. A CP falling on SP position is inverted while a CP on the non-SP-bearing is not inverted. Such a basic principle is also identically applied to the CP patterns

ESTIMATION OF PROPOSED CHANNEL FREQUECNY RESPONSE

We first present the CFR estimation using the proposed SP, EP, and CP falling on SP position, of which operation procedure. Initially temporary channel frequency response is first estimated by using least square approach (LS) on pilot sub carriers. After performing the initial channel frequency response using least square we again perform the channel impulse response using the cascading approach and finally, data sub carriers estimation between output sub carriers. Then output signal and four consecutive OFDM symbol block estimation is done as illustrated in following equation

$$\begin{bmatrix} \widehat{H}_{j,1}^{1}(n,k) \\ \widehat{H}_{j,2}^{2}(n,k) \\ \widehat{H}_{j,3}^{3}(n,k) \\ \widehat{H}_{j,4}^{4}(n,k) \end{bmatrix} = \begin{bmatrix} 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & -1 \\ 1 & 1 & -1 & -1 \\ 1 & -1 & -1 & 1 \end{bmatrix} \begin{bmatrix} \widehat{H}_{j,1}(n,k) \\ \widehat{H}_{j,2}(n,k) \\ \widehat{H}_{j,3}(n,k) \\ \widehat{H}_{j,4}(n,k) \end{bmatrix}$$

From the above equation it is revealed that orthogonal property of channel frequency response can be readily estimated by multiplying the both sides of equation 6. The Channel frequency response equations are estimated by using the statistics gets from the above analysis and it is shown in the following two equations

$$\begin{bmatrix} \widehat{H}_1(n,k) \\ \widehat{H}_2(n,k) \end{bmatrix} = \frac{1}{4} \begin{bmatrix} P_2 & P_2 \\ P_2 & -P_2 \end{bmatrix} \begin{bmatrix} \widehat{H}_1{}^1(n,k) \\ \widehat{H}_2^2\,(n,k) \end{bmatrix}$$

$$\widehat{H}_i{}^i(n,k) = \begin{bmatrix} \widehat{H}_{1,2i-1}^{2i-1}(n,k) & \widehat{H}_{2,2i-1}^{2i-1}(n,k) \\ \widehat{H}_{1,2i}^{2i}(n,k) & \widehat{H}_{2,2i-1}^{2i}(n,k) \end{bmatrix}$$

PROPOSED CIR ESTIMATION

In our proposed framework, we propose the novel proposed CIR estimation, for use in synchronization, FI, and monitoring of a channel environment, by using the TI output (or FI input). In particular, we focus on an efficient CIR estimation rather than accurate CIR estimation. The efficiency is actually realized by employing an $\mathrm{IFFT_c}$. It was show that can be decreased by estimating CIR with a low-resolution, which means that a sample period T'_s of CIR is less than a sample period T_s of OFDM block. In order to take such a benefit, let us first determine N_C as follows

$$N_C = 2^n, if\ 2^n \le \left(\frac{N_I}{N_T \Delta F}\right) < 2^{n+1}$$

The theoretical value of maximum sample delay of a channel being able to be estimated by pilot subcarriers are represented by the above equation. Once Nc is determined, the available pilot subcarriers are selected by discarding pilot sub carriers located at the both edges. Finally without applying the zero padding available sub carriers are fed to $\mathrm{IFFT_c}$.

$$T_s^I = \left(\frac{N_I}{N_C \Delta F}\right) T_s$$

Finally below equations shows the final estimation frequency impulse response estimation when applied on the multiple input sub carriers' and represent the phase offset and FIR final estimation calculation.

$$\tilde{h}^i_{j,i}[n,k'] = \exp\left(\frac{j2\pi k'(i-1)\Delta F}{K_{total}}\right) \times \left(\sum_{q=0}^{N_c-1} \tilde{h}^i_{j,i}[n,q]\, exp\left(\frac{j2\pi qk'}{N_c}\right)\right)$$

$$\begin{bmatrix} \tilde{h}^1_{j,i}(n,k') \\ \tilde{h}^2_{j,i}(n,k') \\ \tilde{h}^3_{j,i}(n,k') \\ \tilde{h}^4_{j,i}(n,k') \end{bmatrix} = \begin{bmatrix} P_2 & P_2 \\ P_2 & -P_2 \end{bmatrix} \begin{bmatrix} \tilde{h}_{j,i}(n,k') \\ \tilde{h}_{j,i}(n,k') \\ \tilde{h}_{j,i}(n,k') \\ \tilde{h}_{j,i}(n,k') \end{bmatrix}$$

$$\begin{bmatrix} \tilde{h}_1(n,k') \\ \tilde{h}_2(n,k') \end{bmatrix} = \frac{1}{4} \begin{bmatrix} P_2 & P_2 \\ P_2 & -P_2 \end{bmatrix} \begin{bmatrix} \tilde{h}^1_1\ (n,k') \\ \tilde{h}_2{}^2(n,k') \end{bmatrix}$$

$$\tilde{h}_i{}^i(n,k') = \begin{bmatrix} \tilde{h}^{\ 2i-1}_{\ 1,2i-1}(n,k') & \tilde{h}^{\ 2i-1}_{\ 2,2i-1}(n,k') \\ \tilde{h}^{\ 2i}_{\ 1,2i}(n,k') & \tilde{h}^{\ 2i}_{\ 2,2i-1}(n,k') \end{bmatrix}$$

SIMULATION RESULTS

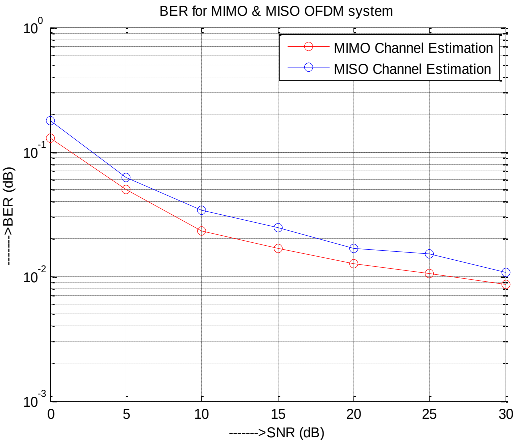

Figure 4 BER performances of the MIMO-OFDM and Conventional MISO-OFDM systems as a function of SNR

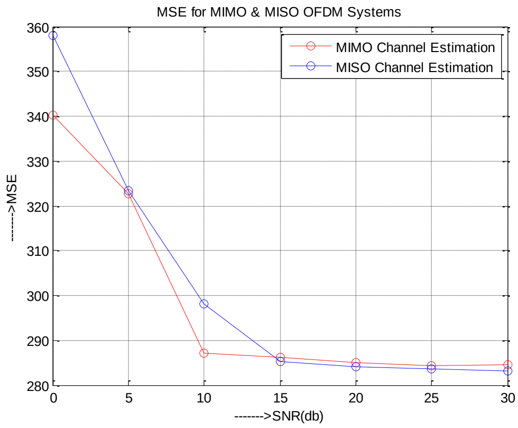

Figure 5 :MSE performances of CIR estimations used for the MIMO-OFDM and
MISO-OFDM systems as a function of SNR

CONCLUSION

In this proposed work, a novel approach for multiple input-multiple outputs orthogonal frequency division multiplexing system is presented based on the two independent and properly distributed considerations. Especially when we compare our proposed MIMO-OFDM with conventional MISO-OFDM, the related comparisons shows the high end performance over the conventional works. The proposed framework presents novel pilot patters such as scattered pilot, continuous pilot and edge pilot in order to estimate the pilot patterns in accurate manner. Finally, the proposed work simulation results evaluation yields high end performance when compare to the conventional works such as multi input-single output OFDM system.

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