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# Channel Matrix Shaping Scheme for MIMO OFDM System in Wireless Channel

Athira. P., Anu Anna John

**Abstract**— Performance enhancement is the key requirement of today's communication world as it proceeds towards a 4G wireless technology. Orthogonal frequency division multiplexing (OFDM) along with Multi Input Multi Output (MIMO) system is an excellent air interface solution to the next generation wireless communication. The advantage of incorporating MIMO technique is to improve the data transmission reliability through diversity and to achieve higher data rate through spatial multiplexing. Space Time Block coding (STBC) with MIMO OFDM System has peerless performance against multipath effects and frequency selective fading whereas Bit Error Rate (BER) and receiver complexity is low. This paper presents a technique to improve the robustness of STBC-OFDM System with multiple transmitting and receiving antennas. The channel matrix of the frequency selective channel is shaped into a piecewise flat fading channel by the proposed scheme. We concentrate on quasi-static Rayleigh fading wireless channel and the technique that achieve good performance at high SNR's. In addition to its higher level performance, the proposed scheme has low computational complexity due to the use of short block length Walsh Hadamard Transform (WHT).

**Index Terms**— Bit Error Rate (BER), Frequency-Selective Channels, MIMO-OFDM, Space Time Block Codes (STBCs).

## 1 INTRODUCTION

IN today's wireless communication, multiple antennas are utilized in transmitter and receiver section in order to build redundancy and hence improve the bit rate of communication system. Multipath fading effects and frequency spectrum utilization are mainly two threats in future wireless communication system. Orthogonal Frequency Division Multiplexing (OFDM) is a FDM scheme that converts the frequency selective channel into piecewise flat fading channel, so it can reduce the impact of fading. Independent parallel transmission channels are produced in space by MIMO technology, so it can transmit multiple data stream at the same time. Hence it can improve the rate of transmission more adequately. The combination of MIMO and OFDM system result in MIMO-OFDM system has both advantages [1].

Transmit Diversity Block Coding (TDBC) or Space Time Block Coding (STBC), an efficient transmit diversity scheme, was first introduced by Alamouti [2] are widely considered in literature [5] and [6]. One of the main advantages of STBC based MIMO system is that it can obtain the same diversity advantage as Maximum Ratio Combining (MRC) for receiver diversity by a Maximum Likelihood Detector (MLD). However this detector is ideal only when the channel is quasi static, i.e., the channel must remain constant over the duration of a space time codeword [2]. Recently, Vielmon et al. [3] investigated the performance of an Alamouti system based on the impact of time-varying channel. To encounter the sudden channel variation they have suggested three new detectors.

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These detectors are the zero-forcing (ZF), decision-feedback (DF), and joint maximum-likelihood (JML) detectors. In the literature, several explanations have been introduced to improve the performance of STBC-OFDM system with multiple antennas in frequency selective channels. For example, Lee and Williams [4] proposed two combinations of TDBC and OFDM, i.e., ST block-coded OFDM (STBC-OFDM) and space–frequency block-coded OFDM (SFBC-OFDM).They uses simple ML detector under the assumption that channel is static over the time of ST/frequency codeword. Lee et al. [5] proposed a hybrid STBC-SFBC (STFBC) system to reduce both frequency and time selectivity of fading channel. In STFBC system managed to combat the BER degradation but gain improvement is limited.

Closed-loop precoding has been widely studied in the literature to improve the BER performance of STBC systems [9].Space Time OFDM with Hadamard precoder have been described in [7], [8].It was shown that the addition of Walsh Hadamard precoder at the transmitter can improve the system performance to particular limit. WHT can be used with single antenna systems also s reported in [10] and [11].However such system provides very limited advantage over conventional OFDM.

In this paper, we present a new technique to augment the robustness of STBC systems by allowing the Maximum Likelihood detector using the transparent STBC decoder unconcerned of the frequency selective channel. The proposed system, which is denoted as STBC Channel Matrix shaping (CMS) system, assures that the channel becomes piece wise flat. STBC-CMS system is based on the 2x2 Walsh Hadamard Transform, which offer slight additional complexity. The most important constraint of the CMS system is that it's best performance is attained with conventional modulation technique like binary phase shift keying (BPSK) modulation.

This paper is organized as follows. Section II gives an overview of MIMO-OFDM System, its model and functions in the area of wireless communication. Section III presents the

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STBC-OFDM system model with multiple transmit and receive antennas. Section IV introduces the proposed STBC-CN
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### 2.1

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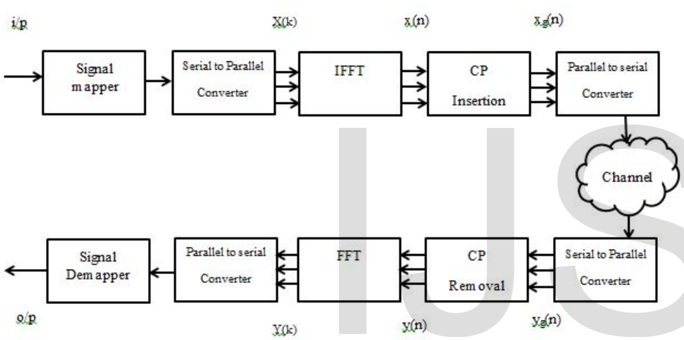


Fig. 1. Block Diagram of a Baseband OFDM transceiver System

Then a serial to parallel converter makes subcarriers ready for processing by IFFT. Now N subcarriers are there and each sub-carrier consists of data symbol X(k) (k=0,1,….,N-1), where k shows the sub-carrier index. These N subcarriers are provided to inverse fast Fourier transform (IFFT) block i.e., the data on the subcarriers are transformed from frequency domain to time domain. After transformation, the time-domain OFDM signal at the output of the IFFT can be written as:

$$x(n)=\sum_{k=o}^{n} X(k)\exp(\frac{2\pi\pi k}{N}) \quad (1)$$

where n is the time domain sample index of an OFDM signal.

After that, Cyclic Prefix (CP) is inserted to each subcarrier blocks by preceding it with the end by a copy of the end part of that same block. Addition of CP (guard interval) before transmission helps to mitigate the Inter Symbol Interference (ISI) and provide robustness. The resulting signal is $x_{cp}$ which is given to the parallel-to-serial converter. It converts the parallel data streams into serial data streams, suitable for transmission over transmit antennas to the frequency selective Rayleigh fading channel and a noisy channel with i.i.d. AWGN noise. The received signal can be written as:

$$y_g(n) = x_g * h(n) + w(n), 0 < N-1 < n \quad (2)$$

where $w$ ($n$) denotes i.i.d. additive white Gaussian noise sample and $h$ ($n$) denotes the discrete time channel impulse response.

The receiver consists of serial to parallel converter, cyclic prefix removal, FFT, parallel-to-serial converter and signal demapper. The serial data received by the receiver is converted into parallel streams with the help of a serial to parallel converter and CP is removed [13]. After removing the CP, the received parallel data stream are sent to a Fast Fourier Transform (FFT) block inorder to get demultiplex the multi-carrier signals. Then the FFT output in frequency domain signal at $k^{th}$ subcarrier is expressed as:

$$Y(k) = \frac{1}{N}\sum_{n=0}^{N-1} y(n)\exp(\frac{-j2\pi2\pi}{N}), 0 \le k \le N-1 \quad (3)$$

### 2.2 MIMO System Model

MIMO system consist multiple antenna elements in both transmitter and receiver. Let us assume that there are $N_t$ no of transmit antennas and $N_r$ no of receive antennas as shown in figure 2.

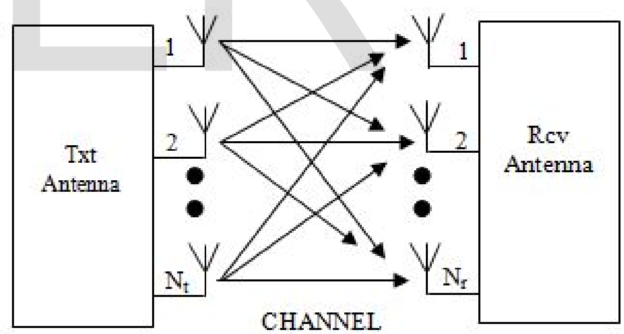


Fig. 2. MIMO channel model

They can achieve both spatial multiplexing gain and spatial diversity gain. There is a channel/path between transmitter and receiver in MIMO system. Thus the channel consists of $N_tN_r$ paths between them. We are considering a flat fading channel for simplicity i.e., it is not frequency selective. The channel behavior is easily expressed by a matrix known as channel matrix with dimension $N_t$ x $N_r$ which is represented by H.

H is also known as channel transfer function. If X represents the transmitted signal vector and Y represents the received signal vector. The transmitted data stream goes through the multipath flat fading channel and it finally reached at the receiver end. This could be expressed as:

$$[H] = \begin{bmatrix} H_{1,1} & H_{1,2} & \cdots\cdots H_{1,Nt} \\ H_{2,1} & H_{2,2} & \cdots\cdots H_{2,Nt} \\ H_{Nr,1} & H_{Nr,2} & \cdots\cdots H_{Nr,Nt} \end{bmatrix} \quad (4)$$

$$Y = Hx + n \quad (5)$$

Where n is the AWGN noise of the same size as $Y$ with zero mean and variance $\sigma_d^2$ (white noise) and $X$ is 1 x $N_t$ vector and $Y$ is $N_r$ x 1 vector. The main three technical advantage of MIMO system is Beamforming technology, Spatial Diversity based on space-time coding and spatial multiplexing. High diversity gain can be achieved by space time coding. It can also reduce the symbol error probability due to channel fading. In MIMO system there exists a fundamental tradeoff between transmit diversity and spatial multiplexing gains.

### 2.3 MIMO OFDM Technology

MIMO system can make use of multi path components only to some extent and it is still powerless against deep frequency selective fading. MIMO system is weak against the channel which is selective in frequency, i.e. because it can make use of multiple path components only to some extent. The two schemes that are used recently to solve the issues related to frequency selective channel are Equalization and the next one is OFDM. One of the problem with OFDM is the limitation to improve the utilization of spectrum. MIMO-OFDM is the foundation for most of the broadband wireless network because of its high spectral efficiency, high capacity and data throughput.

Simplified MIMO-OFDM system block diagram is shown in figure 3. MIMO-OFDM system has $N_t$ transmit antennas and $N_r$ receive antennas so it can provide spatial diversity effect and the impact of frequency fading can also be reduced. This is because multiple transmitter and receiver antenna result in multipath channel, where complete of them will not be fading at identical time.

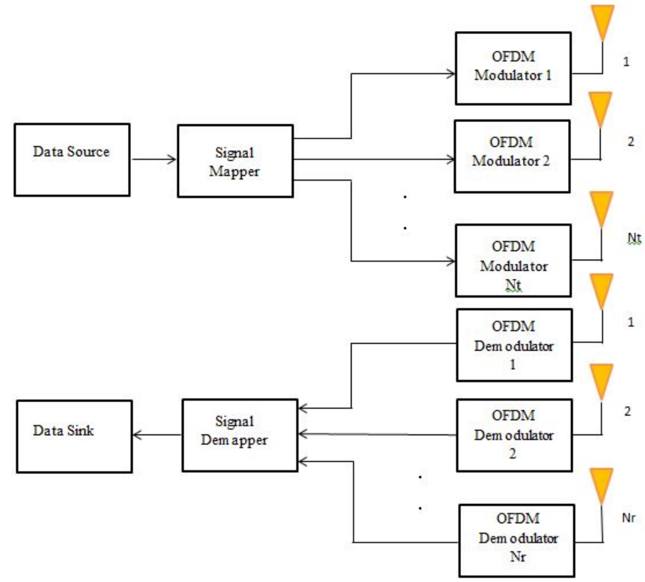


Fig. 3. Block diagram of MIMO-OFDM system

The data streams given to the input get transformed into multiple divisions by Serial Parallel (SP) converter for reliable data transmission. And each branch of data stream will be allowed to perform each of the OFDM processing. This processing includes source coding, signal mapping, data conversion, Transformation by IFFT, insertion of cyclic prefix to each symbol and so on. Then data get transmitted to the frequency selective wireless channel through multiple antennas. Finally at the end where receiver placed, the reverse OFDM signal processing take place inorder to obtain the original data, that was same as that used at transmitter.

## 3 STBC IN MIMO-OFDM SYSTEM

Consider a wireless communication system with N number of transmitting antenna at encoder and decoder contains M number of receiving antennas. The aim of space time coding is to achieve the maximum coding gain, the maximum diversity of NM and the highest data throughput. Space-time block coding is a scheme that provide very low complexity system with multiple transmit antennas.

The input symbols of STBC encoder are divided into 2 groups. $\{a^1, a^2\}$ of each group will be transmitted simultaneously within a given period T. $a^1$ is transmitted from antenna 1 and $a^2$ is transmitted from antenna 2. $-\breve{a}^2$ will be transmitted from antenna 1 and $\breve{a}^1$ is transmitted from antenna 2. Therefore the transmitted codeword (C) is:

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$$C = \begin{bmatrix} a^1 & a^2 \end{bmatrix} \rightarrow \begin{bmatrix} a^1 & -\breve{a}^2 \\ a^2 & a^1 \end{bmatrix} \qquad (6)$$

The two important properties of Alamouti code are simple decoding and maximum diversity. Linear processing can only be used to decode each symbol separately. The Alamouti code satisfies the rank criteria, so it provides full diversity. Consider an Alamouti space-time coded OFDM system with two transmits and two receive antennas .For simplicity, the channel is assumed to be time invariant. If the channel is time invariant over two consecutive OFDM symbols, then the STBC encoder output can be transmitted as STBC-OFDM [ ].Therefore the STBC encoder output for a two consecutive data streams $a^1$ and $a^2$, such that each sequence consists of N data symbols, can be expressed as [2]:

$$\begin{bmatrix} a^1 & a^2 \end{bmatrix} \xrightarrow{\text{STBC}} \begin{bmatrix} a^1 & -\breve{a}^2 \\ a^2 & a^1 \end{bmatrix} \cong \begin{bmatrix} u^{1,1} & u^{1,2} \\ u^{2,1} & u^{2,2} \end{bmatrix} \qquad (7)$$

where ă denotes the complex conjugate of a, and $u^{s,\tau}$ denotes the transmitted block from antenna s at time period τ, $\{s,\tau\} \in \{1,2\}$. In the beginning of transmission, each of the sequence is OFDM modulated i.e. all sequence at the output of STBC encoder go through N-point Inverse Fast Fourier Transform (IFFT). The IFFT output can be expressed as $\mathbf{x}^{s,\tau} = \mathbf{F}^H u^{s,\tau}$ , where $F^H$ is the Hermitian transpose of the normalized $N \times N$ FFT matrix F. To form a complete OFDM symbol, a cyclic prefix of length P samples gets appended at the beginning of each IFFT output. So each OFDM symbol will have $N_t$ = N+P samples and a duration of $T_t$ seconds. Finally these OFDM symbols get upconverted to higher frequency and get transmitted through corresponding antenna and time slot.

At the receiver, the received symbols are down-converted to lower frequency and get sampled at a rate of $T_s=T_t/N_t$. In this paper, we are assuming that the channel between transmit (s) and receive (v) antennas are independent frequency selective Rayleigh fading channel. This channel consist of $L_h^{s,v,\tau}$ + 1 independent multipath components, each path has a gain of $h_l^{s,v,\tau}$ and delay $l^{s,v,\tau}$ x $T_s$. Given that the channel over one OFDM symbol is constant and perfect timing synchronization between transmitter and receiver. After discarding the CP and applying FFT , the received signal can be expressed as

$$r^{\upsilon,\tau} = H^{1,\upsilon,\tau}u^{1,\tau} + H^{2,\upsilon,\tau}u^{2,\tau} + \eta^{\upsilon,\tau} \qquad (8)$$

where η denotes the additive white Gaussian noise with zero mean. H denotes the diagonal matrix that represents the channel frequency response. Since channel remains constant over two consecutive OFDM symbols, the time slot term in (8) can be eliminated from the channel matrix; hence (8) becomes:

$$r^{\upsilon,\tau} = H^{1,\upsilon}u^{1,\tau} + H^{2,\upsilon}u^{2,\tau} + \eta^{\upsilon,\tau} \qquad (9)$$

Therefore the $k^{th}$ term of $r^{v,\tau}$ can be written as:

$$q_k = H_k a_k + \eta_k \qquad (10)$$

where $q_k = \begin{bmatrix} r_k^{1,1} & r_k^{2,1} & \breve{r}_k^{1,2} & \breve{r}_k^{2,2} \end{bmatrix}^T$, $a_k = \begin{bmatrix} a_k^1 & a_k^2 \end{bmatrix}^T$, and

$$\mathcal{H}_k = \begin{bmatrix} H_k^{1,1} & H_k^{2,1} \\ H_k^{1,2} & H_k^{2,2} \\ \breve{H}_k^{2,1} & -\breve{H}_k^{1,1} \\ \breve{H}_k^{2,2} & -\breve{H}_k^{1,2} \end{bmatrix} \qquad (11)$$

Finally the STBC decoder output $s_k$ can be written as:

$$s_k = [\mathcal{H}_k^H \quad \mathcal{H}_k]^{-1} \mathcal{H}_k^H q_k^T \qquad (12)$$

# 4 PROPOSED STBC CHANNEL MATRIX SHAPING SYSTEM (STBC-CMS)

## 4.1 Proposed CMS System Model (Quasi static channel)

In STBC MLD using the Alamouti decoder requires that, $H_k^{1,v} = H_x^{1,v}$, which is very difficult to attain for frequency selective wireless channel. Figure 4 shows the block diagram of the proposed STBC-CMS system. The proposed system is constructed initially by dividing each of the data sequence $a^1$ and $a^2$ given in (7) into two N/2 blocks of symbols, where two symbols are present in each block, i.e.,

$$w_k^1 = \begin{bmatrix} -\breve{a}^1 \\ a^2 \end{bmatrix}, \qquad w_k^2 = \begin{bmatrix} a^2 \\ \breve{a}^1 \end{bmatrix} \qquad (13)$$

Each of the blocks $w_k^1$ and $w_k^2$ is given to 2 x 2 Walsh Hadamard Transform (WHT) which is defined as

$$W = \frac{1}{\sqrt{2}} \begin{bmatrix} 1 & 1 \\ 1 & -1 \end{bmatrix} \qquad (14)$$

which gives

$$g_k^1 = W w_k^1 = \frac{1}{\sqrt{2}} \begin{bmatrix} a_1 - \breve{a}_2 \\ a_1 + \breve{a}_2 \end{bmatrix}$$
$$g_k^2 = W w_k^2 = \frac{1}{\sqrt{2}} \begin{bmatrix} a^2 + \breve{a}^1 \\ a^2 - \breve{a}^1 \end{bmatrix} \qquad (15)$$

These N/2 vectors are combined together to form vectors g1 and g2, where $g^i = \begin{bmatrix} g_0^i & g_1^i & \cdots & g_{\frac{N}{2}-1}^i \end{bmatrix}^T$, $i \in \{1,2\}$. The remaining transmission and reception process are similar to the STBC system described in Section III, except that $\{a^1\ a^2\}$ are replaced by $\{g^1\ g^2\}$. Thus, at the receiver front end, the received signal is given by

$$r^v = H^{1,v}g^1 + H^{2,v}g^2 + \eta^v \qquad (16)$$

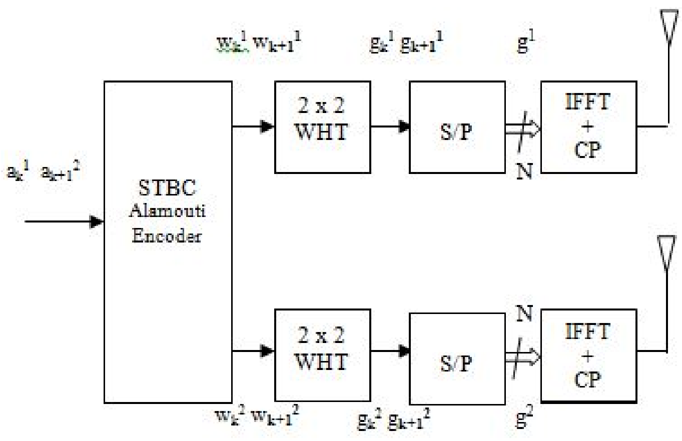


Fig. 4. Block diagram of proposed STBC CMS system

However, because the channel matrices are diagonal, before the STBC decoding process each of the two adjacent subcarriers can be extracted. Thus any block that consists of the samples $r_k^v$ and $r_\alpha^v$, where $\alpha$ = k+1 can be expressed as

$$r_k^v = \begin{bmatrix} H_k^{1,v} & 0 \\ 0 & H_\alpha^{1,v} \end{bmatrix} \begin{bmatrix} g_k^1 \\ g_\alpha^2 \end{bmatrix} + \begin{bmatrix} H_k^{2,v} & 0 \\ 0 & H_\alpha^{2,v} \end{bmatrix} \begin{bmatrix} g_k^2 \\ g_\alpha^2 \end{bmatrix} + \begin{bmatrix} \eta_k^v \\ \eta_\alpha^v \end{bmatrix} \quad (17)$$

Applying the Inverse Walsh Hadamard Transform (IWHT) on $r_k^v$ gives

$$t_k^v = Tr_k^v = \frac{1}{\sqrt{2}} \begin{bmatrix} H_k^{1,v} & H_\alpha^{1,v} \\ H_k^{1,v} & -H_\alpha^{1,v} \end{bmatrix} \begin{bmatrix} g_k^1 \\ g_\alpha^1 \end{bmatrix} + \frac{1}{\sqrt{2}} \begin{bmatrix} H_k^{2,v} & H_\alpha^{2,v} \\ H_k^{2,v} & -H_\alpha^{2,v} \end{bmatrix} \begin{bmatrix} g_k^2 \\ g_\alpha^2 \end{bmatrix} + \begin{bmatrix} \psi_k^v \\ \psi_\alpha^v \end{bmatrix} \quad (18)$$

where the noise vector $\psi^v = T\eta^v$ which has same properties of $\eta^v$. Consider the situation where $a_k = a_\alpha \cong \mathcal{g}$. Thus, $w_k^1 = [\mathcal{g} \quad -\mathcal{g}]^T$, and $w_k^2 = [\mathcal{g} \quad \mathcal{g}]^T$. Thus

$$g_k^1 = \sqrt{2} \begin{bmatrix} 0 \\ \mathcal{g} \end{bmatrix} \quad (19)$$

$$g_k^2 = \sqrt{2} \begin{bmatrix} \mathcal{g} \\ 0 \end{bmatrix} \quad (20)$$

Finally (18) can be rewritten as

$$t_k^v = \underbrace{\begin{bmatrix} H_\alpha^{1,v} & 0 \\ 0 & H_\alpha^{1,v} \end{bmatrix}}_{\Lambda_\alpha^{1,v}} \begin{bmatrix} \mathcal{g} \\ -\mathcal{g} \end{bmatrix} + \underbrace{\begin{bmatrix} H_k^{2,v} & 0 \\ 0 & H_k^{2,v} \end{bmatrix}}_{\Lambda_k^{2,v}} \begin{bmatrix} \mathcal{g} \\ \mathcal{g} \end{bmatrix} + \begin{bmatrix} \psi_k^v \\ \psi_k^v \end{bmatrix} \quad (21)$$

The channel matrices $\Lambda_\alpha^{1,v}$ and $\Lambda_k^{2,v}$ are diagonal with identical elements, hence they can be written as $\Lambda_\alpha^{1,v} = H_\alpha^{1,v} I_2$, $\Lambda_k^{2,v} = H_k^{1,v} I_2$. Thus, (21) can be written as;

$$t_k^v = H_\alpha^{1,v} w_k^1 + H_k^{2,v} w_k^2 + \psi_k^v \quad (22)$$

Therefore the IWHT output of the data subcarriers k and k+1 can be expressed as

$$t_k = \mathcal{H}_k a_k + \psi_k \quad (23)$$

where,

$$t_k = [t_k^1 \quad t_k^2 \quad \breve{t}_\alpha^1 \quad \breve{t}_\alpha^2]^T$$

$$\psi_k = [\psi_k^1 \quad \psi_k^2 \quad \breve{\psi}_\alpha^1 \quad \breve{\psi}_\alpha^2]^T$$

$\psi_k$ is the AWGN noise vector, and

$$\mathcal{H}_k = \begin{bmatrix} H_\alpha^{1,1} & H_k^{2,1} \\ H_\alpha^{1,2} & H_k^{2,2} \\ \breve{H}_k^{2,1} & -\breve{H}_\alpha^{1,1} \\ \breve{H}_k^{2,2} & -\breve{H}_\alpha^{1,2} \end{bmatrix} \quad (24)$$

By comparing the channel matrix in (24) and (11), it can concluded that without any constraint on the channel coefficients the Alamouti decoder (12) can be used to extract the data symbols.

## 4.2 Complexity Analysis

The number of complex multiplications (CMs) and complex addition /subtractions (CAs) are calculated inorder to access the complexity of the STBC-CMS system. At the transmitter, $\mathbb{N}/2$ CMs and $\mathbb{N}$ CAs operations are performed due to the two N-point IFFT. Only 2 CAs are required by 2-point WHT which takes place N/2 times.

At the receiver side, the complexity of IWHT and FFT are same as that of the WHT and IFFT computed at the transmitter. Thus the total number of complex multiplications $(\mathbb{C}_M)$ and additions $(\mathbb{C}_A)$ for the STBC-CMS are $\mathbb{C}_M = 2\mathbb{N} + \mathbb{N}$ and $\mathbb{C}_A = 4(\mathbb{N} + \mathbb{N})$ respectively.

The 2 x 2 unitary precoder STBC system requires two N-point IFFT and WHT, similarly two N- point FFT and IWHT at transmitter and receiver respectively. WHT does not require any multiplication operation as its matrix elements are either 1 or -1. Consequently the proposed STBC-CMS system and unitary precoder STBC will have identical complex multiplications. The complex additions required for WHT/IWHT is $\mathbb{N}$, i.e., computed using Fast WHT algorithm. Therefore the UP-STBC system has $\mathbb{C}_M = 2\mathbb{N} + \mathbb{N}$ and $\mathbb{C}_A = 8\mathbb{N}$. Consequently the relative complexity of STBC-CMS system with respect to UP-STBC is less than 67% for N>64. Moreover, the proposed system requires knowledge of the channel parameters only for half of the subcarriers. Hence the proposed system can significantly relax the complexity of estimating the channel coefficients.

## 5 NUMERICAL RESULTS

The proposed system model considered in this paper make use of an OFDM system with N=64 subcarriers, the number of CP samples P=16 and a multipath Rayleigh frequency selective fading channel.

BER comparison between the BPSK and QPSK modulation in Rayleigh and AWGN channel is given in Fig 5 and Fig 6 respectively. As expected, the BER theoretical and simulation values are almost identical for given SNR's.

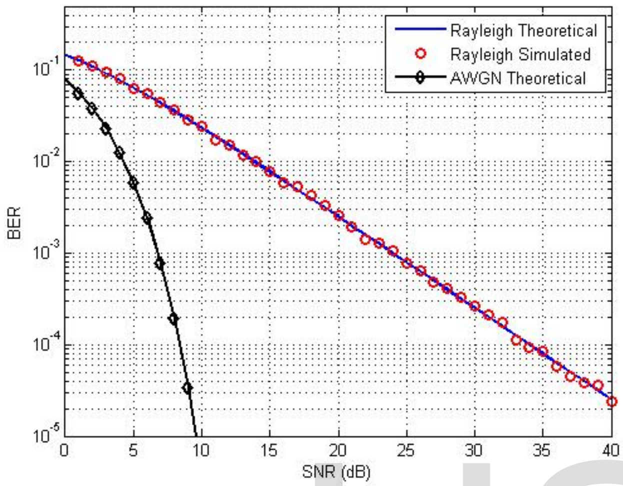


Fig. 5.BER for BPSK over Frequency Selective Rayleigh Channel

From the figure of BPSK over Rayleigh Channel and AWGN channel implies that the amount of energy required for data transmission over Rayleigh channel is greater than the energy required for data transmission over AWGN channel. We also observed that the BER for data transmission over Rayleigh frequency selective channel is greater than for the AWGN channel. From our results, it is clear that the QPSK modulation is preferred in cases where we need to consider small amounts of transmitting energy. Because QPSK gives sufficient BER while transmitting data with relatively lower energy. Figure 6 shows the BER for QPSK over frequency selective Rayleigh and AWGN channel.

Figure 7 presents the BER performance analysis of the single input single output OFDM system over Rayleigh and AWGN channel as a function of OFDM. Figure 8 presents the performance of space time coding in MIMO OFDM system in terms of bit error rate over static frequency selective Rayleigh channel.

Bit error rate performance of space frequency block coding in MIMO OFDM system is depicted in figure 9. Figure 10 compare the performance of conventional STBC and SFBC in OFDM system with multiple transmitting and receiving antennas.

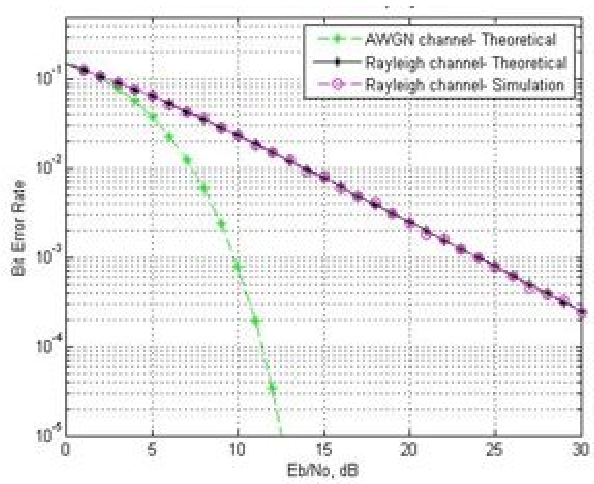


Fig. 6.BER for QPSK over Frequency Selective Rayleigh Channel

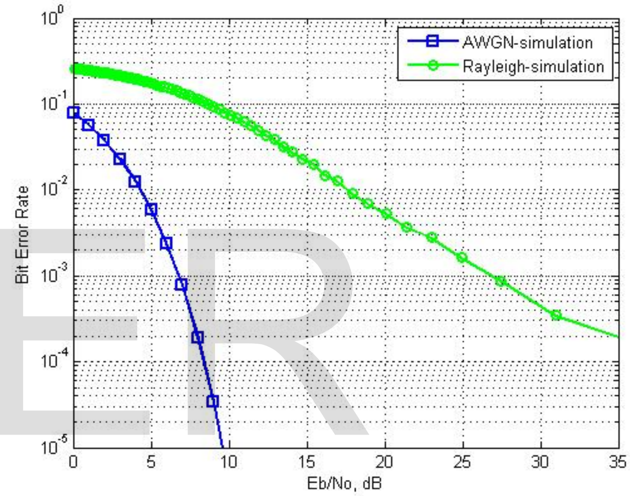


Fig. 7 .BER for BPSK using OFDM over Rayleigh and AWGN Channel

From figure 10 it is clear that conventional STBC shows a slight better performance than conventional SFBC system. Conventional SFBC system suffers from high degradation of BER due to the frequency selectivity of channel. BER performance of the proposed Channel Matrix Shaping (CMS) scheme over static frequency selective Rayleigh channel is given in figure 11. Figure 12 represents the comparison of performance between CMS scheme with conventional SFBC and STBC system in MIMO OFDM.

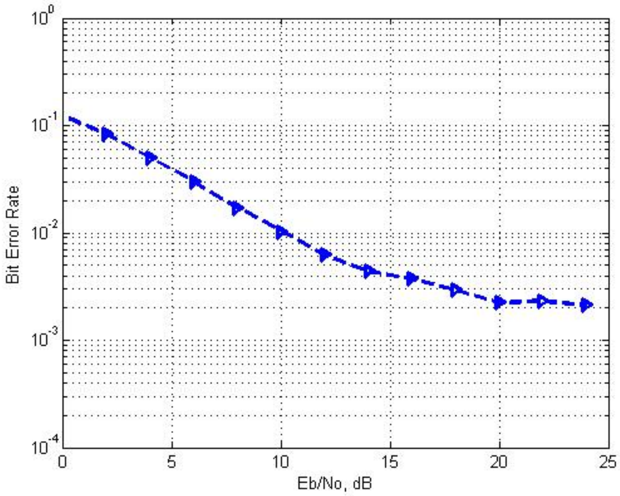


Fig. 8 .BER for STBC MIMO OFDM System over Rayleigh channel

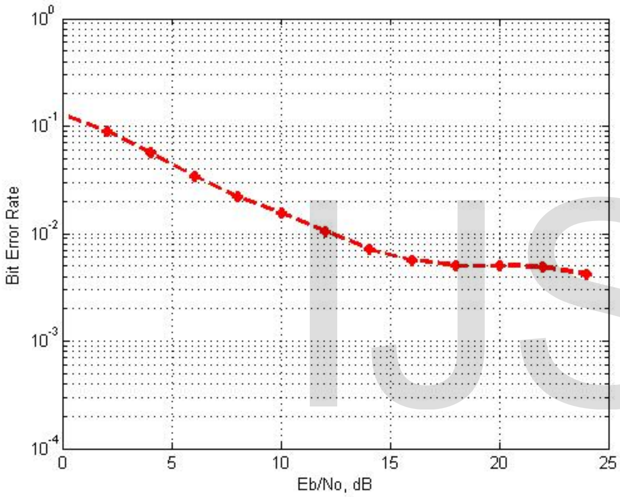


Fig. 9. .BER for SFBC MIMO OFDM System over Rayleigh channel

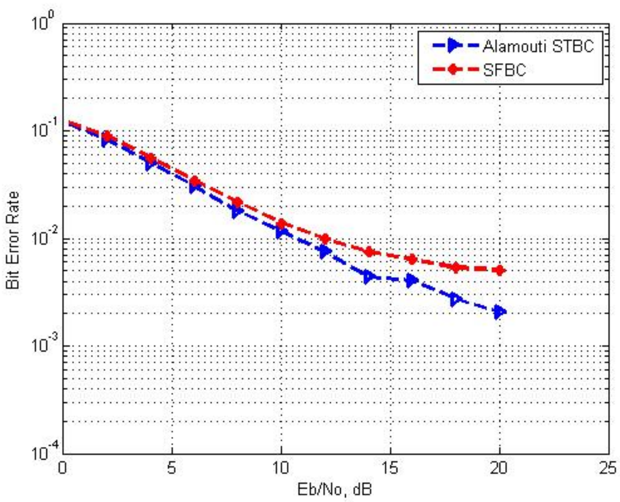


Fig. 10. BER of the STBC and SFBC system in MIMO OFDM over Rayleigh channel

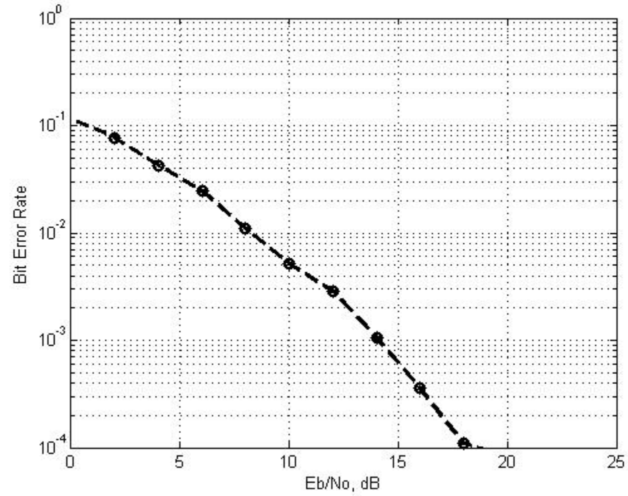


Fig. 12. .BER of the proposed CMS System over Rayleigh channel

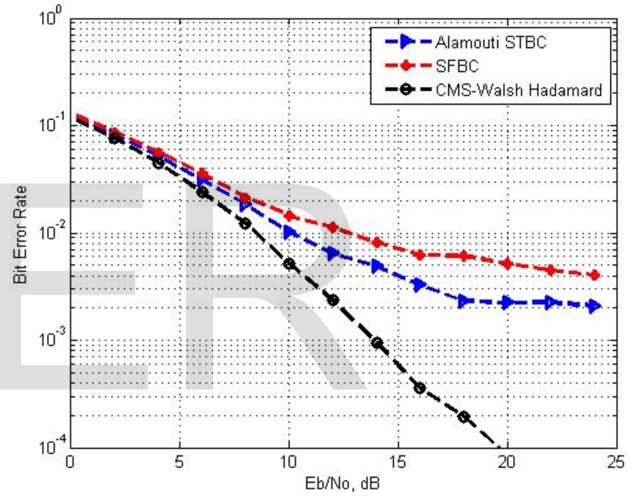


Fig.12. Comparison of Proposed CMS scheme and conventional STBC and SFBC

As expected, the performance of the proposed CMS scheme outperforms the conventional coding scheme in OFDM with multiple antennas at transmitter and receiver end. Figure 12 represents that the CMS system shows high robustness against channel selectivity and improved performance.

## 6 CONCLUSION

This paper explores a new simplified technique to overcome the consequence of the frequency selectivity of the channel in STBC systems. The recommended CMS scheme shapes the matrix of channel and change it into piecewise flat channel over every pair of STBC blocks. This system has low complexity due to the use of short block length 2 X 2 Walsh Hadamard Transform and shows better performance against conventional coding schemes such as STBC and SFBC systems. This scheme is really attractive to opt for adaptive modulation system even in severe communication situation since it is

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optimized for BPSK modulation. In future source coding and forward error correction (FEC) can also be included to improve the performance.

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