PERFORMANCE OF STBC, SPATIAL MULTIPLEXING AND HYBRID TECHNIQUE FOR MIMO OFDM SYSTEM

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ABSTRACT

The objective of the paper is to take advantage of the benefits of both while avoiding their drawbacks combine transmit diversity and spatial multiplexing, thus achieving at the same time the two possible spatial gains offered by MIMO systems .this paper presents the "performance enhancement through increasing number of antennas for ALAMOUTI and STBC codes in MIMO RF systems". Recently many researchers have been working on MIMO systems with STBC to improve the performance of system without additional bandwidth or transmit power requirements. In MIMO system, the transmitter and receiver are equipped with multiple antennas. The MIMO system provides multiple independent channels, so the channel capacity increases linearly with the number of antennas. Space-time block codes have been shown to perform well with Multiple-Input Multiple Output (MIMO) systems. The design aspect of wireless system aims at improvement in spectral efficiency and coverage area with reliable performance. This necessitates that the MIMO system must be capable to overcome data rate limitation and there must have options open for future improvement. the STBC schemes in Rayleigh fading environment using various combinations of numbers of transmit and receive antennas. The simulations results have been obtained in MATLAB.

Keyword: - *MIMO-OFDM, STBC, Spatial multiplexing, Spatial Modulation, Rayleigh fading, BER, QPSK, BPSK, Zero Forcing.*

1. INTRODUCTION

Multiple input multiple output communication pronounced like My-moe, a single processing technique to enhance the execution of wireless correspondence system by using numerous receiving antenna at transmitter side and beneficiary side or both. By combating or exploiting multipath scattering, MIMO techniques improve communication performance in communication channel between a transmitter or receiver. Spatial diversity improves reliability the purpose of spatial multiplexing is to maximize throughput.

MIMO has turned into a key component of remote correspondence measures including Long Term Evolution, IEEE 802.11n, IEEE 802.11ac, WiMAX, HSPA+ (3G)[1].

We utilize different types of coding used space time block code (STBC), MIMO preceding, Alamouti codes and MIMO coding. Space-time block codes are used for MIMO systems to enable the transmission of multiple copies of a data stream across a number of antennas and to exploit the various received versions of the data to improve the reliability of data-transfer. Space-time coding combines all the copies of the received signal in an optimal way to extract as much information from each of them as possible.

In order that MIMO spatial multiplexing can be utilized, it is necessary to add coding to the different channels so that the receiver can detect the correct data. Exactly when using space time block coding, the data stream is encoded in piece before transmission. These data block are passed on among the various getting receiving and the information is likewise dispersed cross space overtime.

We usually represent a space time block code by a matrix. In which line speaks represents for a time slot and each segment is spoken to for one reception apparatus transmission over a period [2].

$$\text{time-slots}\downarrow \overset{\text{transmit antennas}\ \longrightarrow}{\begin{bmatrix} s_{11} & s_{12} & \cdots & s_{1n_T} \\ s_{21} & s_{22} & \cdots & s_{2n_T} \\ \vdots & \vdots & & \vdots \\ s_{T1} & s_{T2} & \cdots & s_{Tn_T} \end{bmatrix}}$$

These two systems are listed below.
1. MIMO implemented using diversity techniques – provides diversity gain – Aimed at improving the reliability
2. MIMO implemented using spatial-multiplexing techniques – provides degrees of freedom or multiplexing gain – Aimed at improving the data rate of the system

1.1 Spatial diversity

In diversity techniques, same information is sent across independent fading channels to combat fading. When multiple copies of the same data are sent across independently fading channels, the amount of fade suffered by each copy of the data will be different. This guarantees that at-least one of the copy will suffer less fading compared to rest of the copies. Thus, the chance of properly receiving the transmitted data increases. In effect, this improves the reliability of the entire system. This also reduces the co-channel interference significantly. This technique is referred as inducing a “spatial diversity” in the communication system [6].

1.2 Spatial Multiplexing

In spatial multiplexing, each spatial channel carries independent information, thereby increasing the data rate of the system. This can be compared to Orthogonal Frequency Division Multiplexing (OFDM) technique, where, different frequency sub channels carry different parts of the modulated data. But in spatial multiplexing, if the scattering by the environment is rich enough, several independent sub channels are created in the same allocated bandwidth. Thus the multiplexing gain comes at no additional cost on bandwidth or power. using spatial multiplexing techniques to exploit multipath in order to achieve higher data rates than are possible with conventional systems having the same bandwidth [4].

2. IMPLEMENTATION

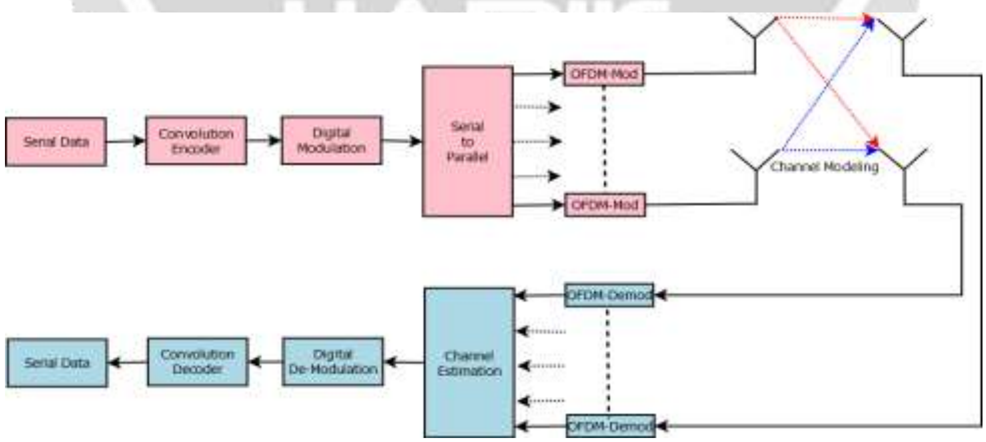


Figure 1: Block diagram of MIMO-OFDM

2.1 Two receiver antenna ALAMOUTI STBC

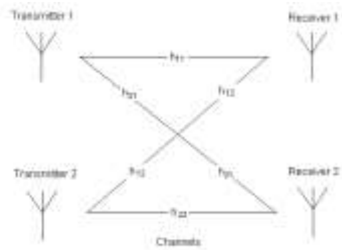


Figure 2: Transmit 2 Receive (2×2) MIMO channel

In the 2×2 system in Figure there is the potential for both transmit and receive diversity. Receive diversity is when the same information is received by different antennas.
For instance the information sent from Tx1 is transmitted across channels h1,1 and h1,2, and received by both Rx1 and Rx2. Transmit diversity is when the same information is sent from multiple transmit antennas. One possible way to achieve this is to code across multiple symbols periods. For instance, at time t antenna Tx1 could transmit the symbol s then at time t+1 antenna Tx2 would transmit the same symbol, s. The Alamouti scheme uses a method similar to this to obtain transmit diversity.

Table 1: Alamouti 2X2

	Transmitter 1	**Transmitter 2**
Time t	x_1	x_2
Time t + T	$-x_2^*$	x_1^*

$$Y = \begin{bmatrix} y_1^2 \\ y_2^2 \end{bmatrix} = \begin{bmatrix} h_{11} & h_{12} \\ h_{21} & h_{22} \end{bmatrix} \begin{bmatrix} -x_2^* \\ x_2^* \end{bmatrix} + \begin{bmatrix} n_1^2 \\ n_2^2 \end{bmatrix}$$

Where $\begin{bmatrix} y_1^1 \\ y_2^1 \end{bmatrix}$ referrers for antennas 1 and 2 the received OFDM symbol at the first time period.

$\begin{bmatrix} n_1^1 \\ n_2^1 \end{bmatrix}$ For antennas 2 and 1 are the noise symbol at the time period first.

$$Y = \begin{bmatrix} y_1^1 \\ y_2^1 \end{bmatrix} = \begin{bmatrix} h_{11} & h_{12} \\ h_{21} & h_{22} \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} n_1^1 \\ n_2^1 \end{bmatrix}$$

Where $\begin{bmatrix} y_1^2 \\ y_2^2 \end{bmatrix}$ referrers for antennas 1 and 2 the received OFDM symbol at the second time period.

$\begin{bmatrix} n_1^2 \\ n_2^2 \end{bmatrix}$ For antennas 2 and 1 are the noise symbol at the time period second.

$$Y = \begin{bmatrix} y_1^1 \\ y_2^1 \\ y_1^{2*} \\ y_2^{2*} \end{bmatrix} = \begin{bmatrix} h_{11} & h_{12} \\ h_{21} & h_{22} \\ h_{12}^* & -h_{11}^* \\ h_{22}^* & -h_{21}^* \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} n_1^1 \\ n_2^1 \\ n_1^{2*} \\ n_2^{2*} \end{bmatrix}$$

Combined equations and arranged to produce the result.

$$y = Hx + n$$

In equation, x is the vector of transmitted signal,
H is the channel matrix,
n is the adding noise vector, and
y is the received signal vector.

Linear detector the Zero Forcing (ZF) is given by,
We to find a matrix W, that satisfies W = HI we know that to solve for x,

$$W = (H^H H)^{-1} H^H$$

For a general matrix m x n , this matrix is familiar as the pseudo inverse.

$$(H^H H)^{-1} = \begin{bmatrix} h_{11}{}^* & h_{21}{}^* \\ h_{12}{}^* & h_{22}{}^* \end{bmatrix} \begin{bmatrix} h_{11} & h_{12} \\ h_{21} & h_{22} \end{bmatrix} = \begin{bmatrix} |h_{11}|^2 + |h_{12}|^2 & h_{11}^* h_{12} + h_{21}^* h_{22} \\ h_{12} h_{11} + h_{21} h_{22} & |h_{12}|^2 + |h_{22}|^2 \end{bmatrix}$$

Using the Zero Forcing (ZF) equalization method, the receiver can get an estimate of transmitted two symbols described above,

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

For receive diversity case equation obtained

$$\mathrm{R = y - h_{ij} x + n}$$

2.2 Spatial Multiplexing with 2x2 antenna

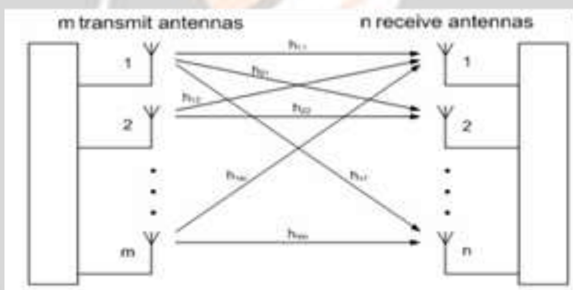


Figure 3: spatial multiplexing system with 2x2

To exploit the extra throughput offered, MIMO wireless frameworks use a network numerical methodology. Antennas 1, 2, 3, .. 4 can transmit information data t1, t2, t3, .. tn To empower the recipient to have the capacity to separate between the distinctive information streams it is important to utilize. At that point there are assortments of ways that can be utilized with every way having diverse channel properties. These can be spoken to by the properties h12, going from transmit antenna 1 to get antenna 2 et cetera. Along these lines for a two transmit, two get antenna framework a grid can be set up

$$r1 = h11t1 + h21\ t2 + h31\ t3 + h41\ t4$$
$$r2 = h12\ t1 + h22\ t2 + h32\ t3 + h42\ t4$$
$$r3 = h13\ t1 + h23\ t2 + h33\ t3 + h43\ t4$$
$$r4 = h14\ t1 + h24\ t2 + h34\ t3 + h44\ t4$$

Where, r1 = at antenna 1 received signal,
r2 = at antenna 2 received signal,
r3 = at antenna 2 received signal,
r4 = at antenna 2 received signal,

Represented format in matrix as below

$$[R] = [H] \times [T]$$

It is important to perform a lot of sign handling to recoup the transmitted information stream tn at the collector. To decide the channel exchange network [H] To begin with individual channel exchange characteristic hij must evaluate the MIMO system decoder. with the inverse of the exchange lattice [H] when every one of this has been evaluated [H] is delivered and the transmitted information streams can be reproduced by multiplying they got vector.

$$[\mathrm{T}] = [\mathrm{H}]^{-1} \times [\mathrm{R}]$$

2.2 Hybrid technique

A Hybrid model is a combination of Spatial Multiplexing and STBC. Hybrid MIMO-OFDM system as shown in figure 4. The input data passed through Spatial multiplexing block into two streams. The output of each block is given to Alamouti STBC with (2x2) antenna configuration. The output of STBC encoder is the input to OFDM transmitter with (4x4) antennas. Then signal is passed through Rayleigh fading channel. AWGN noise added to each signal. Input data stream having symbol s1, s2, s3, s4 are equally divided by Spatial by Spatial Multiplexing and passed through STBC encoder as shown in table 2.

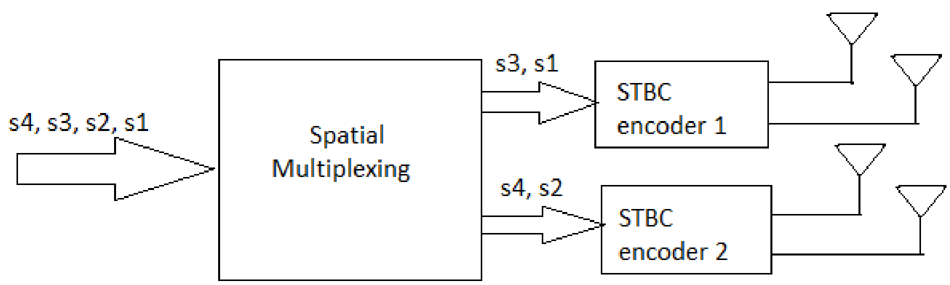


Figure 4: hybrid MIMO model

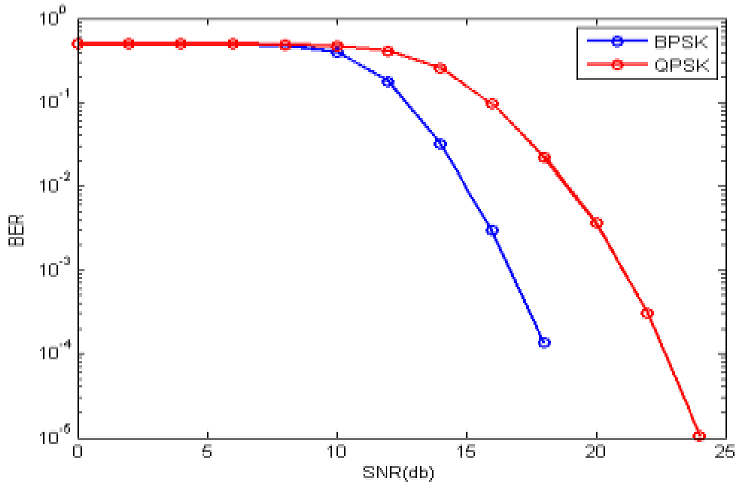
Table 2: hybrid MIMO transmitted signals

Time	Antenna 1	Antenna 2	Antenna 3	Antenna 4
T	S_1	S_3	S_2	S_4
t+1	$-S_3^*$	S_1^*	$-S_4^*$	S_2^*

Hybrid MIMO equations in Matrix form

$$\begin{bmatrix} r11 & r12 \\ r21 & r22 \\ r31 & r32 \\ r41 & r42 \end{bmatrix} = \begin{bmatrix} h11 & h12 & h13 & h14 \\ h21 & h22 & h23 & h24 \\ h31 & h32 & h33 & h34 \\ h41 & h43 & h43 & h44 \end{bmatrix} \begin{bmatrix} S_1 & -S_3^* \\ S_3 & S_1^* \\ S_2 & -S_4^* \\ S_4 & S_2^* \end{bmatrix} + \begin{bmatrix} n11 & n12 \\ n21 & n22 \\ n31 & n32 \\ n41 & n42 \end{bmatrix}$$

3. SIMULATION RESULTS



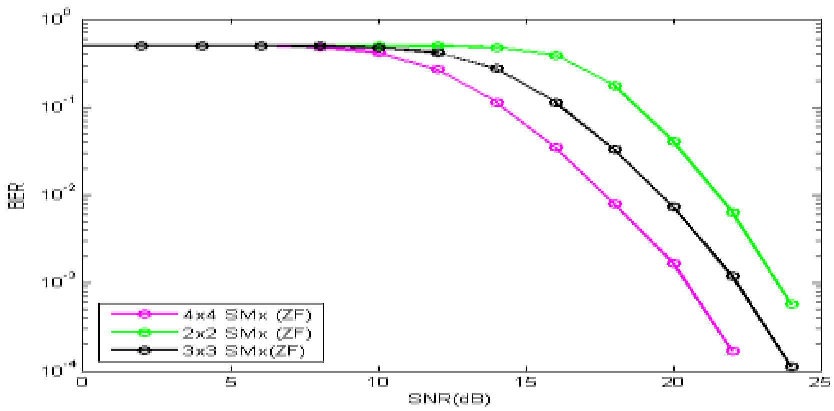
Graph -1: BPSK v/s QPSK

Graph 1 shows comparison of BPSK v/s QPSK modulation. We observe 6 dB SNR gap between BPSK and QPSK. The complete simulation work has been done in MATLAB.

Table -3: comparison between BPSK & QPSK

Modulation techniques	BER value At 15 db SNR
BPSK	10^{-2}
QPSK	10^{-1}

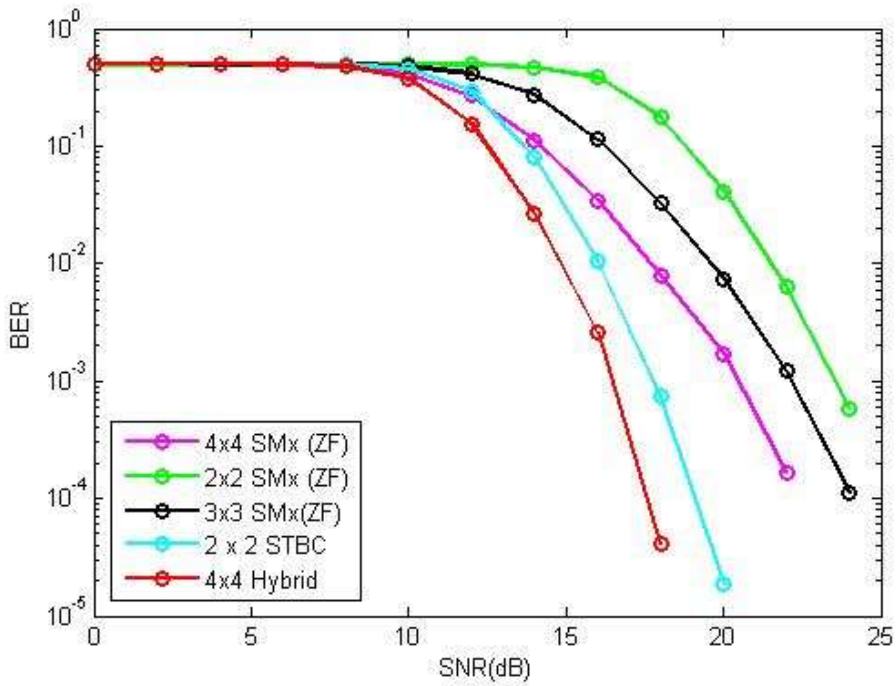
The graph 2 shows BER of spatial Multiplexing MIMO scheme for different numbers of antennas. Result is observed in BER vs. SNR. Also simulation is done for 0-25db SNR. We observed for spatial multiplexing for 4x4 the BER of 10^{-4} at 22 db SNR.
The number of antennas increasing at transmitter & receiver side will achieve better BER.



Graph -2: Comparison between different transmitting antennas in Spatial Multiplexing

Table -4: Comparison between Spatial multiplexing antenna schemes

Antenna scheme for Spatial multiplexing	BER value At 20 db SNR
4x4	10^{-3}
3x3	10^{-2}
2x2	10^{-2} < BER < 10^{-1}



Graph -3: hybrid results compared with STBC and Spatial Multiplexing

Table -5: comparison of Hybrid , STBC and Spatial Multiplexing

Antenna scheme	BER value At 17 db SNR
Hybrid 4x4	10^{-4}
2x2 STBC	10^{-3}
4x4 SMx	10^{-2}
3x3 SMx	10^{-1}
2x2 SMx	10^{-1}<BER <10^{0}

To take advantage of the benefits of spatial diversity and spatial multiplexing, while avoiding their drawbacks combine transmit diversity and spatial multiplexing, which is hybrid. Thus achieving at the same time the two possible spatial gains offered by MIMO systems.
Graph 3 shows the result of hybrid with compared to different antennas of spatial multiplexing (zero forcing equalizer) and spatial diversity (2Tx, 2Rx). Hybrid gives better result than other techniques.

4. CONCLUSIONS

In this paper we obtained comparison of spatial multiplexing for number of different antennas. Spatial multiplexing technique with 2 transmit 2 receive antennas, 3 transmit 3 receive and 4 transmit 4 receive antennas using Zero forcing equalizer. The number of antennas increasing at transmitter & receiver side will achieve better BER. We obtained comparison between MIMO STBC 2Tx, 2Rx and spatial multiplexing. BER significantly less in STBC as compared spatial multiplexing. Spatial multiplexing is best choice for the applications where speed or data transmission rate is having primary importance than BER. We studied the performance of MIMO Transmit diversity Start with 2 transmitting antennas for data communication. To reduce the interference between channels and to increase speed and throughput this technique is used.
Spatial multiplexing gives higher throughput, gives twice data rate. The speed is higher and BER is less in spatial diversity. The result of hybrid with compared to different antennas of spatial multiplexing (zero forcing equalizer) and spatial diversity (2Tx, 2Rx).
We conclude that hybrid is more benefit than transmit diversity and spatial multiplexing. We also conclude increasing number of antenna gives better performance. In capacity formula capacity is increases with increase number of antennas.

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