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# Performance analysis of Novel coding technique suitable for time varying Wireless Communication Systems using Multiple Input Multiple Output

**[1] DHARMESH M. PATEL, [2] ASHISHGOUD PURUSHOTHAM, [3] G.USHA RANI,**

**[1] M.Tech Student, JDCT, Indore,**

**[2] Prof. & Head EC, JDCT, Indore**

**[3] Asst. Prof. EC, JDCT, Indore**

**dharmesh55873@yahoo.co.in, ashishgoudp@gmail.com ,usharanigodugu@gmail.com**

***Abstract—****This paper presents highly robust coding technique suitable for multiple-input multiple-output (MIMO) system. MIMO seems to be the only solution for today's hostile wireless communication system. It has been found that the use of multiple antennas at either transmitter or receiver greatly improves the reception of Rayleigh faded signal. So time is to search for coding technique suitable for MIMO environment. This work presents Space Frequency Block Coding (SFBC) technique that improves the performance of multipath signals of wireless communication systems. it can be observed by the analysis of space time block codes (STBC) and SFBC that SFBC is the close choice of MIMO as far as frequency faded channel is concerned. This work discusses the combinations of multiple antennas at either transmitter and or receiver and shows that increase in number of antennas gives rise to bit error rate (BER) which is one of the important measure of link reliability.To show the conclusion, comparison has been using SFBC coded three transmit and multiple receive antennassystems. It is found that SFBC coding plays important role in increasing data rate and provide diversity gain and as the number of antennas increases either in transmitter or in receiver side, it provides diversity gain. Thisgreatly improves the performance of wireless communication channel in Rayleigh faded environment.*

***Keywords****-multiple input multiple output, space frequency block code, turbo coding, diversity, Rayleigh channel*

## I. INTRODUCTION

The design of the LTE physical layer (PHY) is heavily influenced by the requirements for high peak transmission rate(100 Mbps DL/50 Mbps UL), spectral efficiency, and multiple channel bandwidths (1.25-20 MHz). To fulfill theserequirements, orthogonal frequency division multiplex (OFDM) was selected as the basis for the PHY layer. OFDMis a technology that dates back to the 1960's. It was considered for 3G systems in the mid-1990s before beingdetermined too immature. Developments in electronics and signal processing since that time has made OFDM amature technology widely used in other access systems like 802.11 (WiFi)[1] and 802.16 (WiMAX)[2] and broadcastsystems (Digital Audio/Video Broadcast – DAB/DVB).In addition to OFDM, LTE implements multiple-antenna techniques such as MIMO (multiple input multiple output)which can either increase channel capacity (spatial multiplexing) or enhance signal robustness (spacefrequency/time coding). Space Time Codes (STC) are designed to achieve the diversity gains of MIMO. Space-Time Codes (STC) were first introduced by Tarokh et al. from AT&T research labs [3]in 1998 as a novel means of providing transmit diversity for the multiple-antenna fading channel.Previously, multipath fading in multiple antenna wireless systems was mostly dealt with by otherdiversity techniques, such as temporal diversity, frequency diversity and receive antenna diversity,with receive antenna diversity being the most widely applied technique. However, it is hard to efficiently use receive antenna diversity at the remote units because of the need for them to remainrelatively simple, inexpensive and small. Therefore, for commercial reasons, multiple antennas arepreferred at the base stations, and transmit diversity schemes are growing increasingly popularas they promise high data rate transmission over wireless fading channels in both the uplink anddownlink while putting the diversity burden on the base station.

The space-time coding scheme by Tarokh et al. [3][4][5], is essentially a joint design of coding, modulation,transmit and receive diversity, and has been shown to be a generalization of other transmitdiversity schemes, such as the bandwidth efficient transmit diversity scheme by Witneben [6] andthe delay diversity scheme by Seshadri and Winters [7].
There are two main types of STCs, namely space-time block codes (STBC) and space-time trelliscodes (STTC). Space-time block codes operate on a block of input symbols, producing a matrixoutput whose columns represent time and rows represent antennas. In contrast to single-antennablock codes for the AWGN channel, space-time block codes do not generally provide coding gain,unless concatenated with an outer code. Their main feature is the provision of full diversity witha very simple decoding scheme. On the other hand, space-time trellis codes operate on one inputsymbol at a time, producing a sequence of vector symbols whose length represents antennas. Liketraditional TCM (trellis coded modulation) for a single-antenna channel, space-time trellis codesprovide coding gain. Since they also provide full diversity gain, their key advantage over space-timeblock codes is the provision of coding gain. Their disadvantage is that they are extremely hard todesign and generally require high complexity encoders and decoders.

We start with a model of the multiple antenna system as shown in Figure 1. This is followed by a discussion ofAlamouti's two-antenna transmit diversity scheme in relation to maximum ratio combining (MRC) scheme.

Paper is organized like this. Section II gives basics ofsystem model. Section III describes Space Time Block Codes. Space Frequency Block Codes (SFBC) is described in section IV. Simulation results are explained in section V and conclusion is drawn in section VI.

## II. SYSTEM MODEL

Consider a mobile communication system where the base station is equipped with n transmit and the remote unit is equipped with m receive antennas (see Figure 1). At each time slots *t*, signals $c_t^i, i = 1,2,\cdots,n$ are transmitted simultaneously through *n* transmit antennas.The channel is flat-fading and the path gain from transmit antenna i to receive antenna j is denoted by hi,j. The path gains are modeled as samples of independent complex Gaussian random variables with variance 0.5 per real dimension, i.e.$h_{i,j}\sim$ N (0,1), as we assume that signals received at different antennas experience independent fading. In this report, we will consider modeling the path gains in both slow and fast Rayleigh fading. For slow fading, it is assumed that the path gains are constant during a frame of length L and vary from one frame to another, i.e., channel is quasi-static.

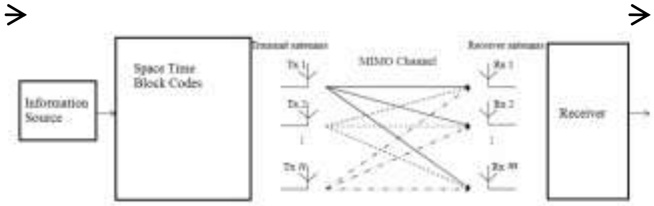


Fig 1 System blockdiagram [8]

At time t, the signal $r_t^i$, received at antenna *j* is given by

$$r_t^j = \sum_{i=1}^{n} h_{i,j} c_t^i + \eta_t^j (1)$$

where the noise samples $\eta_t^j$ are i.i.d. zero mean complex Gaussian with variance $\sigma^2 = \frac{1}{\left(\frac{2E_S}{N_O}\right)} = 1/(2SNR)$per dimension. The average energy of the symbols transmitted from each antenna is normalized to one, so that the average power of the received signal at each receive antenna is n.

It is assumed that channel state information is only available at the receiver, who uses it tocompute the decision metric

$$\sum_{t=1}^{l} \sum_{j=1}^{m} \left| r_t^j - \sum_{i=1}^{n} h_{i,j} c_t^i \right|^2 \quad (2)$$

overall codewords

$$c_1^1, c_1^2, \cdots, c_1^n, \quad c_2^1, \cdots c_2^n, c_2^1, \cdots, c_l^n$$

and decide in favor of the code word that minimizes the sum.

## III. SPACE TIME BLOCK CODES

In 1998, Alamouti [9] proposed a simple transmit diversity scheme (see Figure (2)), which improves the signal quality at the receiver on one side of the link by simple processing across two transmit antennas at the opposite end.

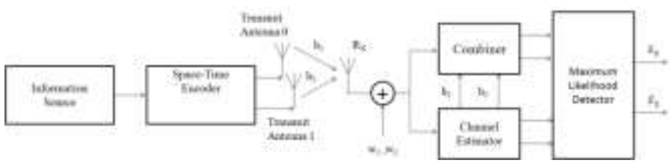

Figure 2 Alamouti's STBC coding scheme [10]

At a given symbol period, two signals are simultaneously transmitted from the two antennas, namely $c_1$ from the first antenna, Tx1, and $c_2$ from the second antenna, Tx2. In the next symbol period, signal $-c_2^*$ is transmitted from Tx1 and signal $c_1^*$ is transmitted from Tx2, where $*$ denotes complex conjugation.

Following is the symbol matrix as per Alamouti scheme.[10]

$$C = \begin{bmatrix} c_1 & -c_2^* \\ c_2 & c_1^* \end{bmatrix} \quad (3)$$

If we assume that the fading is constant across two consecutive symbols, we can write

$$h_1(t) = h_1(t+T) = h_1 = \alpha_1 e^{j\theta_1} \quad (4)$$
$$h_2(t) = h_2(t+T) = h_2 = \alpha_2 e^{j\theta_2}$$

where$T$ is the symbol period. The received signals are

$$r1 = r(t) = h_1 c_1 + h_2 c_2 + \eta_1 \quad (5)$$
$$r2 = r(t+T) = -h_1 c_2^* + h_2 c_1^* + \eta_2 ,$$

where$r_1$ and $r_2$ are the received signals at time $t$ and $t + T$.

The combiner combines the received signals as follows:

$$\tilde{c}_1 = h_1^* r_1 + h_2 r_2^* = (\alpha_1^2 + \alpha_2^2) c_1 + h_1^* \eta_1 + h_2 \eta_2^*$$
$$\tilde{c}_2 = h_2^* r_1^* - h_1 r_2^* = (\alpha_1^2 + \alpha_2^2) c_2 - h_1 \eta_2^* + h_2^* \eta_1 \quad (6)$$

and sends them to the maximum likelihood detector. Maximum likelihood detector decides on base of minimum Euclidean distance the one who is received out of those transmitted. Several combining techniques are developed to effectively combine the received signals from many received antennas. Alamouti further extended this scheme to the case of 2 transmit antennas and m receive antennas and showed that the scheme provided a diversity order of 2m.

## IV. SPACE FREQYEBCT BLOCK CODES

Similar to STBC presented in previous section, SFBC for two transmit antennas requires two time slots to transmit the $X_2^C$ matrix. However, in contrast with STBC, only one symbol is required as data is coded across frequencies.

SFBC consists of symbol $c_k$and $-c_{k+1}^*$ are transmitted alternatively from antenna 1 while $c_{k+1}$and $c_k^*$are transmitted in a similar way from antenna 2.

Due to the fact that data symbols are transmitted within one OFDM symbol, the received signal can be expressed as:

$$R_j(n) = \sum_{j=1}^{N_R} H_{1,j}(n) C_1(n) + H_{2,j}(n) C_2(n) + \eta_j(n) \quad (7)$$

where$Wj(n)$ is the white Gaussian noise. Data vector $C_1(n)$and $C_2(n)$can also be expressed as:

$$X_1 = [x_0, -x_1^*, \ldots, x_k, -x_{k+1}^*, \ldots, x_{N-2}, -x_{N-1}^*]^T$$

$$X_2 = [x_1, x_0^*, \ldots, x_{k+1}, x_k^*, \ldots, x_{N-1}, x_{N-2}^*]^T (8)$$

where k = 0, 2, …, N – 1.

Data symbols can be recovered using only one symbol, therefore, *n* has been omitted and will be omitted for the rest of this Section.

Assuming that channel parameters remain constant over two consecutive subcarriers and that channel parameters are known at the receiver. After FFT operation is performed, received data is sent to the SFBC decoder. Following the derivation of the single carrier STBC case, it can be derived that:

$$\begin{aligned} \tilde{c}_k &= \sum_{j=1}^{N_R}\left(h_{1,j,k}^* r_{j,k} + h_{2,j,k} r_{j,k+1}^*\right) \\ \tilde{c}_{k+1} &= \sum_{j=1}^{N_R}\left(h_{2,j,k}^* r_{j,k} - h_{1,j,k} r_{j,k+1}^*\right) \end{aligned} \quad (9)$$

Data is then sent to the ML decoder and to the demapper to recover the transmitted stream.

Later on Alamouti's transmit diversity scheme was generalized to an arbitrary number of transmit antennas, and more complex space-frequency block codes were presented. These codes require no channel state information at the transmitter, achieve maximum-likelihood decoding through linear processing at the receiver, and exhibit maximum diversity. For real signal constellations (such as PAM), they are known to provide the maximum possible transmission rate allowed by the theory of STC. For complex constellations, SFBCs can be constructed for any number of transmit antennas, and they provide full spatial diversity and half of the maximum possible rate allowed by the theory of STC.
An SFBC is defined by a p × n transmission matrix G, whose entries are linear combinations of $c_1, \cdots, c_k$ and their conjugates $c_1^*, \cdots, c_k^*$, and whose columns are pairwise-orthogonal. In the case when *p* = *n* and $\{c_i\}$ are real, G is a linear processing orthogonal design which satisfies the condition that $G^T G = D$, where *D* is a diagonal matrix. Without loss of generality, the first row of *G* contains entries with positive signs; if not, one can always negate certain columns of *G* to arrive at a positive first row. Equation (7) include the 2 × 2 and 3 × 4 design. In this design, $G_2$ stands for full rate and $G_3^c$ stands for rate half code.

$$G_2 = \begin{bmatrix} c_1 & -c_2^* \\ c_2 & c_1^* \end{bmatrix}, and$$

$$G_3^C = \begin{bmatrix} c_1 & c_2 & c_3 \\ -c_2 & c_1 & -c_4 \\ -c_3 & c_4 & c_1 \\ -c_4 & -c_2 & c_2 \\ c_1^* & c_2^* & c_3^* \\ -c_2^* & c_1^* & -c_4^* \\ -c_3^* & c_4^* & c_1^* \\ -c_4^* & -c_3^* & c_2^* \end{bmatrix} (10)$$

Transmission using a generalized orthogonal design is similar to the case when *p* = *n*, except that now kb bits are sent during each *p* transmissions. Since *p* time slots are used to transmit *k* symbols, the rate *R* of this coding scheme is defined to be *kb*/*pb* = *k*/*p*. The diversity order remains *nm*.

## V. Simulation Results

Simulation is carried out by consideringMIMO systems described in section III. It is assumed that the channel state information is completely available at receiver. Also perfect synchronization and zero carrier offset is assumed at the receiver. Here comparison is made amongdifferent combinations of input and output antennas. SFBC coded data is transmitted through wireless channel. Rayleigh fading is implemented in all systems. It is assumed that the antennas are uncorrelated with one another. Quadrature Amplitude Modulation (QAM) is considered for all the simulations. Simulations are carried out using 4 QAM and 16 QAM modulations for the system specified in section II.

Figure 3 shows the simulation results of STBC Alamouti based 2 x 2 and 2 x 1 multiple antenna combinations. It can be observed from the figure that as the number of antennas increase, BER improves.

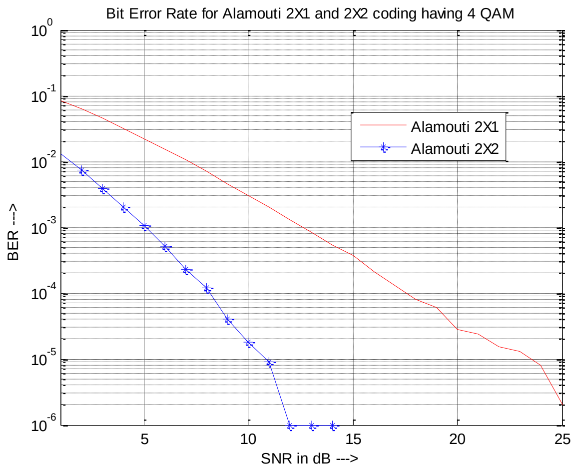


Figure 3BER Plot for Alamouti 2 x 1 with 16 QAM

Figure4 gives the result of comparison of 4 QAM and 16 QAM using 2 x 1 and 2 x 2 antenna configurations.

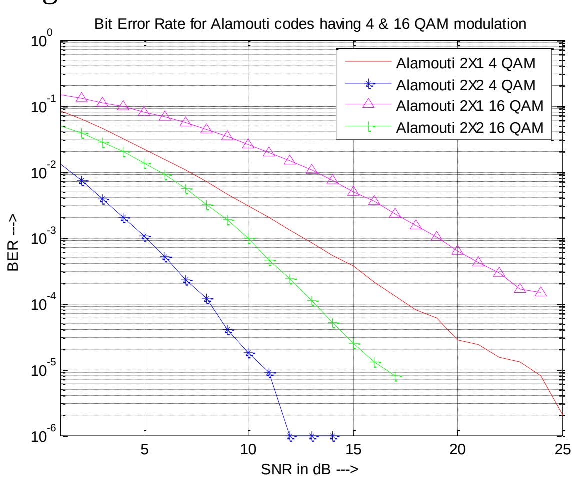


Figure 4 Comparison of Alamouti STBC for 4 Qam and 16 QAM

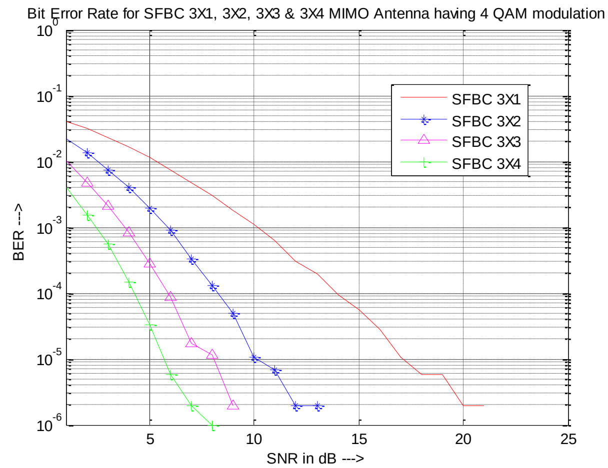


Figure 5 Comparison of 3 x m MIMO for 4 QAM

Figure 5 gives comparison of various MIMO systems having 3 transmit and 1 to 4 receive antennas. It has been observed that as the receive antenna increases, BER improves.

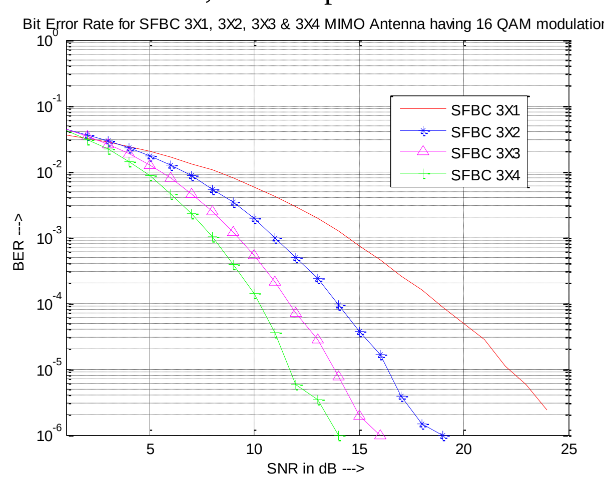


Figure 6 Comparison of 3 x m MIMO for 16 QAM

Figure 6 gives BER comparison among rate half SFBC codes having 3 × 1, 3 × 2, 3 × 3 and 3 × 4 antenna configurations. This plot is generated using 16 QAM modulations. Once again we can observe that as the diversity order increases, BER improves. So to achieve desired BER even for higher modulation orders, if we increase the number of antennas either at transmit or at receive side, it gives desired probability of error.

## VI. CONCLUSION

From Figure 3 to Figure 6, it can be seen that for the AlamoutiSTBC, as the diversity order increase, BER improves. For 2 transmit and 1 receive antenna, diversity of 2 is achieved and so BER gives better results compared to SISO. But as the number of receive antenna also increase by 2, diversity further improves and becomes 4. This is reflected in the curve of BER and a large amount of fall in BER is observed as SNR increases beyond 6 or so.

Also it can be seen that the modulation order of the system causes an upward or downward shift in the performance curve. Higher modulation order implies higher BER but more efficient use of bandwidth while low modulation order reduces the BER at the cost of bandwidth inefficiency.

From the results of figure 5 and 6 it is found that the diversity gain of SFBC improves as the diversity order increases. This is reflected on the BER graph in terms of increasing the number of receive antennas. As the receive antenna increases by one, more than 3 dB gain in BER is observed for every increase in SNR after 6. Simulation results of figure 4shows that using two transmit antennas and one receive antenna provides diversity order less than that of two transmit antenna and two receive antennas. Due to this BER for 2 x 2 is better than 2x1.

## REFERENCES

[1] "Requirements for further advancement for evolved universal terrestrial radio access (E-UTRA) (LTE-Advanced)," 3GPP, Tech. Rep., 2008.

[2] "IEEE standard for local and metropolitan area networks part 16: Air interface for broadband wireless access systems amendment 3: Advanced air interface," IEEE STD 802.16m-2011 (Amendment to IEEE STD 802.16-2009), Tech. Rep., May 5 2011.

[3] V. Tarokh, N. Seshadri, and A.R. Calderbank, "Space-time codes for high data rates wireless communications: Performance criterion and code construction," IEEE Trans. Inform. Theory, vol. 44, pp. 744-765, 1998.

[4] V. Tarokh, H. Jafarkhani, and A.R. Calderbank, "Space-time block coding from orthogonal designs," IEEE Trans. Inform. Theory, vol. 45, pp. 1456-1467, 1999.

[5] V. Tarokh, H. Jafarkhani, and A.R. Calderbank, "Space-time block coding for wireless communications: Performance results," IEEE Journal on Select Areas in Communications, vol. 17, pp. 451-460, 1999.

[6] A. Wittneben, "A new bandwidth efficient transmit antenna modulation diversity scheme for linear digital modulation," in Proceedings of the ICC, 1993.

[7] N. Seshadri and J. H. Winters, "Two signaling schemes for improving the error performance of frequency-division-duplex (fdd) transmission systems using transmitter antenna diversity," Int. J. Wireless Inform., vol. 1, 1994.

[8] J. Mietzner, R. Schober, L. Lampe, W. H. Gerstacker, "Multiple-antenna techniques for wireless communications – a comprehensive literature survey," IEEE Communication Surveys & Tutorials, vol. 11, pp. 87-105, 2009.

[9] S. M. Alamouti, "A Simple Transmit Diversity Technique for Wireless Communications" *IEEE Journal on Selected Areas in Communications*, 16(8):1451–1458, October 1998.

[10] J. Mietzner, R. Schober, L. Lampe, W. H. Gerstacker, "Multiple-antenna techniques for wireless communications – a comprehensive literature survey," IEEE Communication Surveys & Tutorials, vol. 11, pp. 87-105, 2009.