Sandeep Kumar Singh, Anjana Jain, Anurag Shrivastav / International Journal of Engineering Research and Applications (IJERA) ISSN: 2248-9622 www.ijera.com
Vol. 2, Issue 3, May-Jun 2012, pp. 619-624

Performance Analysis of Different Space Time Block Codes

Sandeep Kumar Singh*, Anjana Jain, Anurag Shrivastav*****
* (Department of Electronics and Telecommunication, SGSITS, Indore (M.P.), India)
** (Department of Electronics and Telecommunication, SGSITS, Indore (M.P.), India)
*** (Department of Electronics and Telecommunication, SGSITS, Indore (M.P.), India)

ABSTRACT
To achieve high data rates and good error performance in wireless communication is the main challenge in last ten years. MIMO systems with multiple antenna elements at both link ends are an efficient solution for future wireless communications systems as they provide high data rates by exploiting the spatial domain under the constraints of limited bandwidth and transmit power. Space-Time Block Coding (STBC) is a MIMO transmit strategy which exploits transmit diversity and high reliability. The objective of this paper is to provide the description of different type of space time block codes and to provide the performance analysis of these codes with different schemes. We propose new space time block code and compare it with other codes.

Keywords - **MIMO systems, full diversity, linear receivers, OSTBC, Q-OSTBC.**

I. INTRODUCTION
In the last decade, there has been a dramatic increase in the demand for higher data rates in cellular networks, wireless local area networks and high-definition audio and video broadcasting services. Providing wireless access to the Internet and multimedia services requires an increase in data rates. One of the most significant and promising advances in wireless communications that can meet the demand for higher data rates is the use of multiple antennas at the transmitter and receiver. Deploying multiple antennas at the transmitter and receiver creates a multiple-input multiple-output (MIMO) channel that not only offers higher transmission rates, but it can also improve the system's reliability and robustness to noise compared to single antenna systems.

Signal transmission over the wireless channel suffers not only from additive noise, but also from multipath fading. Specifically, a transmitted radio signal propagates through multiple paths, due to scattering and reflections from different objects in the environment, before it reaches the receiver antenna. At the receiver due to multipath fading, the received signal can be significantly attenuated and the receiver cannot correctly detect the transmitted signal.

One way to overcome the problem of multipath fading is diversity. The basic concept of diversity is to transmit the same information symbols over multiple channels that are fading independently. This way, if one of the channels is in a deep fade, the receiver can still recover the transmitted signal if one of the other channels is in a good enough state to allow for reliable detection.

1.1 Transmit and Receive Diversity
In most scattering environments, antenna diversity is a practical, effective and, hence, a widely applied technique for reducing the effect of multipath fading. The classical approach is to use multiple antennas at the receiver and perform combining or selection and switching in order to improve the quality of the received signal. The major problem with using the receive diversity approach is the cost, size, and power of the remote units. A base station often serves hundreds to thousands of remote units. It is therefore more economical to add equipment to base stations rather than the remote units. For this reason, transmit diversity schemes are very attractive [1].

1.2 Space Time Coding
A key idea in multiple antenna systems is space-time coding, in which the time dimension inherent in digital communications is complemented by the spatial dimension inherent in the use of multiple antennas. A key benefit of space-time coding is the ability to turn multipath propagation, into a benefit for multiple antenna systems by taking advantage of the random fading in increasing the transmission rate of the communication link as well as increase its reliability. The purpose of space time coding is to achieve maximum diversity gain as well as high data rate.

1.3 Focus and Outline of the paper
The objective of this paper is to provide the basics of space time block codes and propose a new scheme. This paper is organized as follows. In Section II, we describe the model of space time block codes. In Section III, we present the different type of space time block codes and their property. In section IV, We give the simulation result and performance comparison of different space time block codes with different schemes. In Section V, Some conclusions are offered. Although the list of references is not intended to be exhaustive, the cited papers (as well as the references therein) will serve as a good starting point for further reading.

II. SPACE TIME BLOCK CODES

2.1 Transmission Model

We consider a wireless communication system with N antennas at the base station and M antennas at the remote. At each time slot t, signals c_i^t $,i=1,2,\ldots N$ are transmitted Simultaneously from the N transmit antennas. The channel is assumed to be a flat fading channel and the path gain from transmit antenna i to receive antenna j is defined to be α_i^j . The path gains are modeled as samples of independent complex Gaussian random variables with variance 0.5 per real dimension. This assumption can be relaxed without any change to the method of encoding and decoding [33]. The wireless channel is assumed to be quasi-static so that the path gains are constant over a frame of length and vary from one frame to another.

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

$$r_t^j = \sum_{i=1}^{n} \alpha_{i,j}\, c_t^i + n_t^j \qquad \ldots\ldots\ldots\ldots\ldots.. (1)$$

where the noise samples η_t^j are independent samples of a zero-mean complex Gaussian random variable with variance n /(2 SNR) per complex dimension. The average energy of the symbols transmitted from each antenna is normalized to be one, so that the average power of the received signal at each receive antenna is n and the signal-to-noise ratio is SNR.

Assuming perfect channel state information is available, the receiver computes the decision metric

$$\sum_{t=1}^{l} \sum_{j=1}^{m} \left| r_t^j - \sum_{i=1}^{n} \alpha_{i,j}\, c_t^i + n_t^j \right|^2 \qquad \ldots\ldots\ldots\ldots\ldots. (2)$$

Over all codeword

$$c_1^1 c_1^2 \ldots c_1^n c_2^1 c_2^2 \ldots c_2^n \ldots c_l^1 c_l^2 \ldots c_l^n$$

And decides in favor of the code word that minimizes the sum.

2.2 Encoding Algorithm

A space–time block code is defined by a $P\times N$ transmission matrix G. The entries of the matrix are linear combinations of the variables $X_1X_2\ldots\ldots X_k$ and their conjugates. The number of transmission antennas is N and we usually use it to separate different codes from each other. For example, G_2 represents a code which utilizes two transmit antennas and is defined by

$$G_2 = \begin{pmatrix} X_1 & X_2 \\ -X_2^* & X_1^* \end{pmatrix} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

We assume that transmission at the baseband employs a signal constellation A with 2^b elements. At time slot 1, kb bits arrive at the encoder and select constellation signals $S_1S_2S_3\ldots..S_K$. Setting for $S_i= X_i$ for i=1,2,3…. in G, we arrive at a matrix C with entries linear combinations of $S_1S_2S_3\ldots..S_K$ and their conjugates. So, while G contains indeterminate $X_1X_2\ldots\ldots X_k$,C contains specific constellation symbols (or their linear combinations) which are transmitted from N antennas for each kb bits as follows. So the ith column of C represents the transmitted symbols from the i th antenna and the t th row of C represents the transmitted symbols at time slot t. Note that C is basically defined using G , and the orthogonality of G's columns allows a simple decoding scheme which will be explained in the sequel.

Since P time slots are used to transmit K symbols, we define the rate of the code to be R=K/P. For example, the rate of G2 is one. Next we review the decoding of these codes.

2.3 The Decoding Algorithm

Maximum likelihood decoding of any space–time block code can be achieved using only linear processing at the receiver. The space–time block code (first proposed by [2]) uses the transmission matrix in (3). Suppose that there are 2^b signals in the constellation. At the first time slot 2b bits arrive at the encoder and select two complex symbols S_1 and S2. These symbols are transmitted simultaneously from antennas one and Two, respectively. At the second time slot, signals $-S_2^*$ and S_1^* are transmitted simultaneously from antennas one and two, respectively.

Then maximum likelihood detection amounts to Minimizing the decision metric

$$\sum_{j=1}^{m} \left(\left| r_1^j - \alpha_{1,j} S_1 - \alpha_{2,j} S_2 \right|^2 + \left| r_2^j + \alpha_{1,j} S_2^* - \alpha_{2,j} S_1^* \right|^2 \right)$$

Over all possible values of S_1 and S_2. Note that due to the quasi-static nature of the channel, the path gains are constant over two transmissions. The minimizing values are the receiver estimates of S_1 and S_2, respectively.

III. TYPES OF SPACE TIME BLOCK CODES

Now I am discussing quasi-orthogonal space time block codes. First I explained ALAMOUTI code then orthogonal space time blocks codes and quasi orthogonal space time block code. Then different schemes for quasi-orthogonal space time block codes discussed. Last I explain proposed code.

3.1 ALAMOUTI Code

Historically, the ALAMOUTI code is the first STBC that provides full diversity at full data rate for two transmit antennas [2]. The information bits are first modulated using an M-ary modulation scheme. The encoder takes the block of two modulated symbols S_1 and S_2 in each encoding operation and hands it to the transmit antennas according to the code matrix

$$S = \begin{bmatrix} S_1 & S_2 \\ -S_2^* & -S_1^* \end{bmatrix} \qquad \ldots\ldots\ldots\ldots\ldots (4)$$

The first row represents the first transmission period and the second row the second transmission period. During the first transmission, the symbols S_1 and S_2 are transmitted simultaneously from antenna one and antenna two respectively. In the second transmission period, the symbol S_2^* is transmitted from antenna one and the symbol $-S_1^*$ from transmit antenna two. It is clear that the encoding is performed in both time (two transmission intervals) and space domain (across two transmit antennas). The two rows and columns of S are orthogonal to each other and the code matrix is orthogonal.

3.2 ORTHOGONAL SPACE TOME BLOCK CODE

The theory of orthogonal designs is an arcane branch of mathematics which was studied by several great number

theorists including Radon and Hurwitz. The encyclopedic work of Geramita and Seberry [28] is an excellent reference. A Classical result in this area is due to Radon who determined the set of dimensions for which an orthogonal design exists [29]. Radon's results are only concerned with real square orthogonal designs.
In this OSTBC TAROKH code [3], they extend the results of Radon to both nonsquare and complex orthogonal designs and introduce a *theory of generalized orthogonal designs*. Using this theory, they construct space–time block codes for any number of transmit antennas.

3.3 QUASI-ORTHOGONAL SPACE TIME BLOCK CODE

The main characteristic of the codes designed in [3] is the orthogonality property of the codes. The codes are designed using *orthogonal designs* which are transmission matrices with orthogonal columns. It is shown how simple decoding which can separately recover transmit symbols is possible using an orthogonal design. In Quasi orthogonal space time block code (JAFARKHANI code) [27], we propose structures that are not orthogonal designs and, therefore, at the decoder, cannot separate all transmitted symbols from each other. Instead, in Quasi OSTBC structure, the transmission matrix columns are divided into groups. While the columns within each group are not orthogonal to each other, different groups are orthogonal to each other. We call such a structure a quasi-orthogonal design. It is shown that using a quasi-orthogonal design, pairs of transmitted symbols can be decoded separately. The application of such a structure is in designing codes which provide higher transmission rates while sacrificing the full diversity.
By using the orthogonality of the transmitted symbols, ALAMOUTI [2] first defined a space time transmission matrix as

$$A_{1,2} = \begin{bmatrix} X_1 & X_2 \\ -X_2^* & X_1^* \end{bmatrix} \qquad \ldots\ldots\ldots\ldots\ldots\ldots (5)$$

Where the subscript $A_{1,2}$ indicates the indeterminate X_1 and X_2 existing in the transmission matrix. Based on ALAMOUTI orthogonal STBC, JAFARKHANI [27] gave a quasi orthogonal STBC form for four transmit antennas as

$$C_J = \begin{bmatrix} A_{1,2} & A_{3,4} \\ -A_{3,4}^* & A_{1,2}^* \end{bmatrix} = \begin{bmatrix} X_1 & X_2 & X_3 & X_4 \\ -X_2^* & X_1^* & -X_4^* & X_3^* \\ -X_3^* & -X_4^* & X_1^* & X_2^* \\ X_4 & -X_3 & -X_2 & X_1 \end{bmatrix} \qquad \ldots\ldots\ldots (6)$$

Where A_{12} and A_{34} are ALAMOUTI codes. Further, different from JAFARKHANI scheme, the TBH case [31] has

$$C_J = \begin{bmatrix} A_{1,2} & A_{3,4} \\ A_{3,4} & A_{1,2} \end{bmatrix} = \begin{bmatrix} X_1 & X_2 & X_3 & X_4 \\ -X_2^* X_1^* & & -X_4^* & X_3^* \\ X_3 & X_4 & X_1 & X_2 \\ -X_4^* X_3^* & & -X_2^* & X_1^* \end{bmatrix} \qquad \ldots\ldots\ldots (7)$$

Using a unitary pattern idea introduced in [34] to investigate the distribution of conjugates in the transmission matrices, we find that it is related to the positions of correlated values. By changing the distribution of conjugates, we can obtain matrices with different positions of correlated values.

3.3.1 JAFARKHANI Case with TBH Correlated Position
We change the conjugates' distribution of JAFARKHANI matrix, and let

$$C_{JT}^{H} = \begin{bmatrix} X_1 & X_2 & X_3 & X_4 \\ -X_2^* & X_1^* & -X_4^* & X_3^* \\ X_4 & -X_3 & -X_2 & X_1 \\ -X_3^* & -X_4^* & X_1^* & X_2^* \end{bmatrix} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (8)$$

3.3.2 TBH case with JAFARKHANI- correlated positions
Similar to the above modification, we exchange the last row and the third row from eqn. (7) and let

$$C_{TJ}^{H} = \begin{bmatrix} X_1 & X_2 & X_3 & X_4 \\ X_2^* & -X_1^* & X_4^* & -X_3^* \\ X_4^* & -X_3^* & X_2^* & -X_1^* \\ X_3 & X_4 & X_1 & X_2 \end{bmatrix} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (9)$$

3.4 ABBA Code

ABBA codes [31], [32], a class of QSTBC, have been proposed to increase the rate of orthogonal space-time block codes (OSTBC). ABBA QSTBC also has low complexity pair wise complex-symbol decoding and performs better than OSTBC. ABBA codes have been widely studied for coherent and non-coherent transmissions, beamforming, and others. The ABBA codes enable pair-wise real-symbol (PWRS) decoding; and call such codes minimum decoding complexity (MDC) codes. Thus, not only is their code rate higher than that of OSTBC, but also their decoding complexity is equal to that of OSTBC.

3.5 Proposed Code

We proposed a new space time block code matrix whose performance is better than other space time block codes. This space time block code is quasi-orthogonal in nature. We use zero-forcing technique for the analysis of this code. Channel is assumed to be quasi-static Rayleigh flat fading channel. The matrix of the proposed code is given by

$$A = \begin{bmatrix} X_1 & X_2 & X_3 & X_4 \\ -X_2^* & X_1^* & -X_4^* & X_3^* \\ X_3 & X_4 & -X_1 & -X_2 \\ -X_4^* & X_3^* & X_2^* & -X_1^* \end{bmatrix} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (10)$$

IV. SIMULATION RESULT AND PERFORMANCE COMPARISION

In simulation result, first we give the comparison of ALAMOUTI space time block codes with 1×1 scheme. We also provide comparison with 1×2 MRC scheme. The comparison of analytical and simulation result is also given. ALAMOUTI scheme is better than other schemes but there is 3-dB difference between ALAMOUTI scheme and (1×2) MRC scheme. Reason is that in ALAMOUTI scheme the signal power is divided in 2 antennas equally.

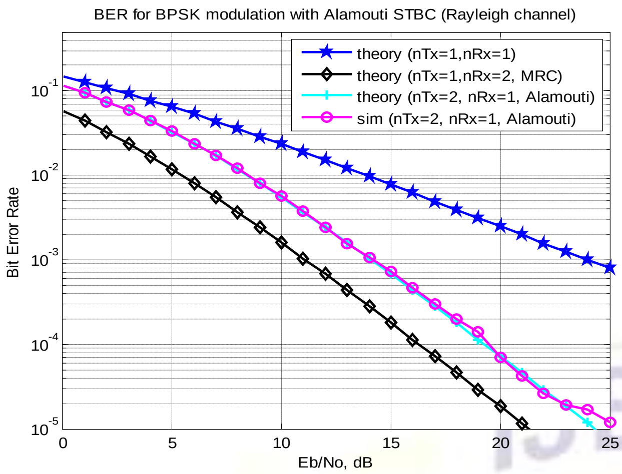

FIG 1: BER performance of ALAMOUTI STBC with different scheme

In next results, we give comparisons of all the space time block codes explained in this paper. The codes are compared under the different modulation schemes like psk and qam modulation. We see that the proposed code has better performance than other codes under different modulation schemes. Linear receiver techniques like zero forcing are used in simulation model. Channel is assumed to be quasi-static flat fading Rayleigh channel.

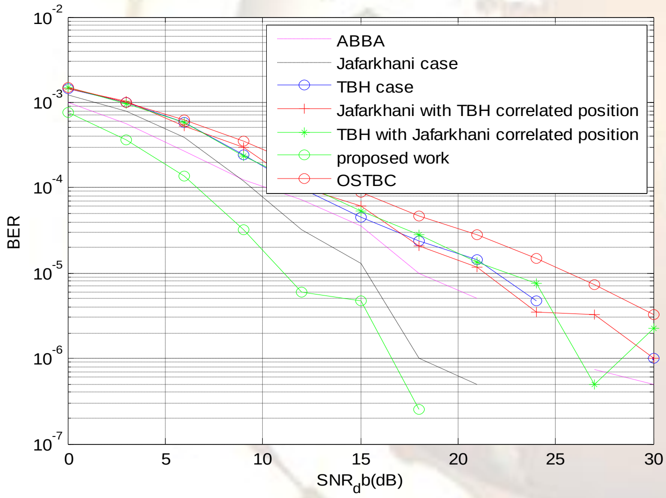

FIG 2: BER performance comparisons of different STBC under 8 PSK scheme

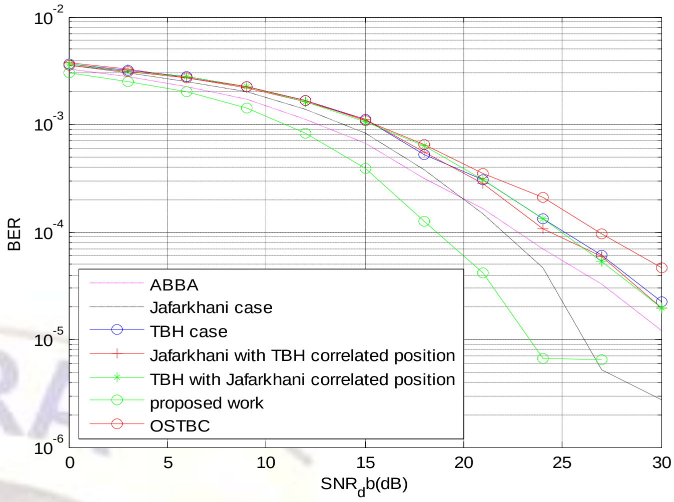

FIG 3: BER performance comparisons of different STBC under 32 PSK scheme

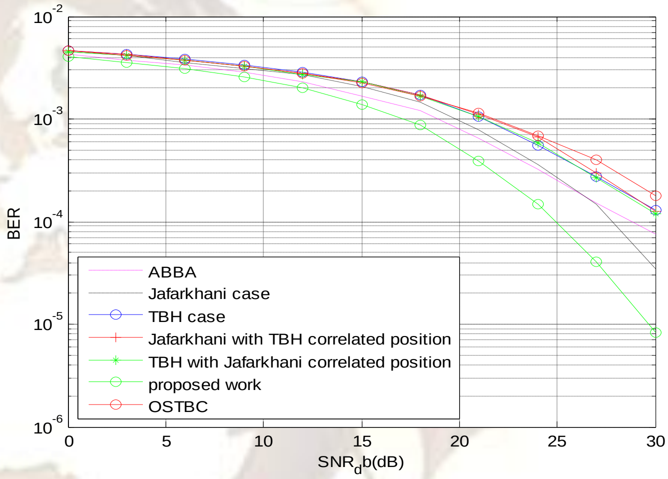

FIG4 : BER performance comparisons of different STBC under 64 PSK scheme

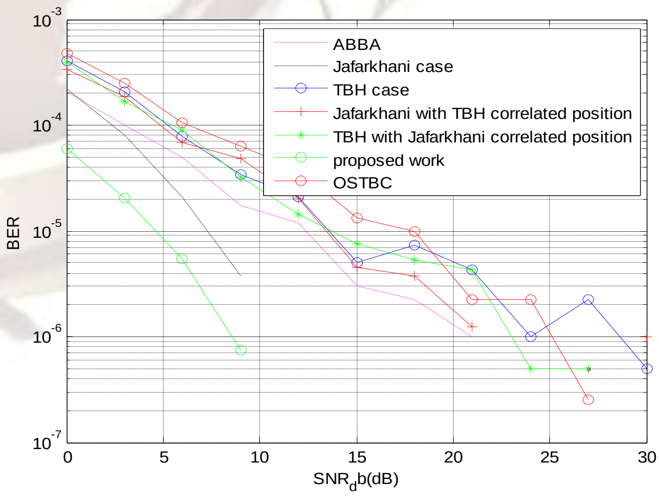

FIG 5: BER performance comparisons of different STBC under 32 QAM scheme

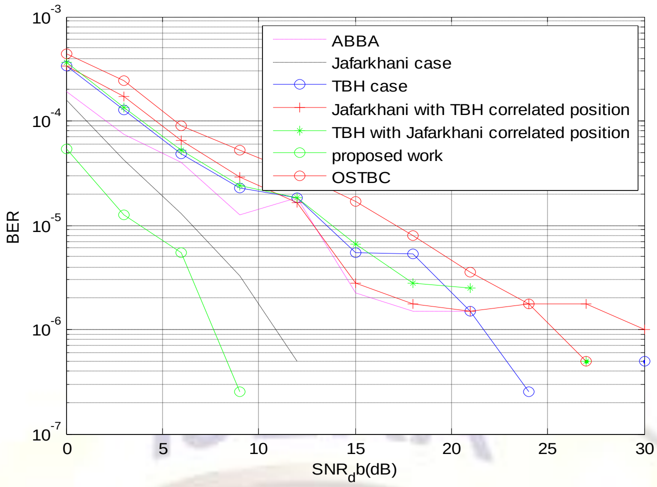

FIG 6: BER performance comparisons of different STBC under 64 QAM scheme

Analyzing all the results, we find that proposed code has better result than other space time block codes under linear receiver.

V. CONCLUSION

In this paper we give the modeling of space time block codes. ALAMOUTI space time block code is based upon this modeling. We explain different space time block codes with their code matrix. Finally we give comparisons of the different space time block codes and show that proposed space time block code is showing better results comparing with different cases. Further, there is a scope of research in M×N space time block codes.

REFRENCES

[1] J.-C. Guey, M. P. Fitz, M. R. Bell, and W.-Y. Kuo, “Signal design for high data rate wireless communication systems over Rayleigh fading channels,” in *Proc. IEEE Vehicular Technology Conf.*, pp. 136–140, 1996.

[2] S. M. Alamouti, “A simple transmitter diversity scheme for wireless communications,” *IEEE J. Select. Areas Commun*, vol. 16, pp. 1451– 1458, Oct. 1998.

[3] V. Tarokh, H. Jafarkhani, and A. R. Calderbank, “Space-time block codes from orthogonal designs,” *IEEE Trans. Inform. Theory*, vol. 45, pp. 1456–1467, July. 1999.

[4] M. O. Damen, A. Tewfik, and J. C. Belfiore, “A construction of a space time code based on number theory,” *IEEE Trans. Inform. Theory*, vol. 48, pp. 658–661, Mar. 2002.

[5] A. V. Geramita and J. Seberry, “Orthogonal design, quadratic forms and hadamard matrices,” in *Lecture Notes in Pure and Applied Mathematics*, (New York: Marcel Dekker INC), 1979.

[6] G. Ganesan and P. Stoica, “Space-time block codes: a maximum SNR approach,” *IEEE Trans. Inform. Theory*, vol. 47, pp. 1650–1656, May. 2001.

[7] O. Tirkkonen and A. Hottinen, “Square-matrix embeddable space-time codes for complex signal constellations,” *IEEE Trans. Inform. Theory*, vol. 48, pp. 1122–1126, Feb. 2002.

[8] X.-B. Liang, “Orthogonal designs with maximal rates,” *IEEE Trans. Inform. Theory*, vol. 49, pp. 2468–2503, Oct. 2003.

[9] X.-B. Liang and X.-G. Xia, “Nonexistence of rate one space-time blocks from generalized complex linear processing orthogonal designs for more than two transmit antennas,” in *International Symposium on Inform. Theory*, (Washington DC), June. 2001.

[10] W. Su and X.-G. Xia, “Two generalized complex orthogonal space-time block codes of rates 7/11 and 3/5 for 5 and 6 transmit antennas,” in *International Symposium on Inform. Theory*, (Washington DC), June. 2001.

[11] H. Wang and X.-G. Xia, “Upper bounds of rates of complex orthogonal space-time block codes,” in *International Symposium on Inform. Theory*, (Lausanne, Switzerland), June. 2002.

[12] S. Sandhu and A. J. Paulraj, “Space-time block coding: A capacity perspective,” *IEEE Commun. Letters*, vol. 4, pp. 384–386, Dec. 2000.

[13] B. Hassibi and B. M. Hochwald, “High-rate codes that are linear in space and time,” *IEEE Trans. Inform. Theory*, vol. 50, pp. 1804–1824, Jul. 2002.

[14] R. W. Heath and A. J. Paulraj, “Linear dispersion codes for MIMO systems based on frame theory,” *IEEE Trans Signal Processing*, vol. 50, pp. 2429–2441, Oct. 2002.

[15] B. A. Sethuraman, B. S. Rajan, and V. Shashidhar, “Full-diversity, high rate space-time block codes from division algebras,” *IEEE Trans. Inform. Theory*, vol. 49, pp. 2596–2616, Oct. 2003.

[16] J.-K. Zhang, J. Liu, and K. M. Wong, “Trace-orthonormal full diversity cyclotomic linear dispersion codes,” in *Proceedings IEEE International Symposium on Information Theory*, (Chicago), June 2004.

[17] P. Dayal and M. K. Varanasi, “An optimal two transmit antenna spacetime code and its stacked extensions,” in

Asilomar Conf. on Signals, Systems and Computers, (Monterey, CA), Nov. 2003.

[18] J. C. Belfiore and G. Rekaya, "Quaternionic lattices for space-time coding," in *Proceedings IEEE of ITW2003*, (Paris, France), March 2003.

[19] J. C. Belfiore, G. R. Rekaya, and E. Viterbo, "The Golden code: A 2×2 full rate space-time code with non-vanishing determinants," in *Proceedings IEEE International Symposium on Information Theory*, (Chicago), June 2004.

[20] G. Rekaya, J. C. Belfiore, and E. Viterbo, "Algebraic 3 × 3, 4 × 4 and 6×6 space-time codes with non-vanishing determinants," in *ISITA*, (Parma, Italy), Oct. 2004.

[21] G. Wang and X.-G. Xia, "Optimal multi-layer cyclotomic space-time code designs," in *Proceedings IEEE International Symposium on Information Theory*, (Chicago), June 2004.

[22] J.-K. Zhang, G.-Y. Wang, and K. M. Wong, "Optimal norm form integer space-time codes for two antenna MIMO systems," in *Int. Conf. Acoust., Speech, Signal Process.*, (Philadelphia, USA), March 2005.

[23] G.-Y. Wang, J.-K. Zhang, Y. Zhang, and K. M. Wong, "Space-time code designs with non-vanishing determinants based on cyclic field extension families," in *Int. Conf. Acoust., Speech, Signal Process.*, (Philadelphia, USA), March 2005.

[24] J. Hiltunen, C. Hollanti, and J. Lahtonen, "Dense full-diversity matrix lattices for four transmit antenna MISO channel," in *Proceedings IEEE International Symposium on Information Theory*, (Adelaide, Australia), pp. 1290–1294, Sept. 2005.

[25] T. Kiran and B. S. Rajan, "STBC-schemes with nonvanishing determinant for certain number of transmit antennas," *IEEE Trans. Inform. Theory*, vol. 51, pp. 2984–2992, Aug. 2005.

[26] F. Oggier, G. Rekaya, J.-C. Belfiore, and E. Viterbo, "Perfect space time block codes," *IEEE Trans. Inform. Theory*, vol. 52, pp. 3885–3902, Sept. 2006.

[27] H. Jafarkhani, "A quasi-orthogonal space-time block codes," *IEEE Trans. Commun.*, vol. 49, pp. 1-4, Jan. 2001

[28] A. V. Geramita and J. Seberry, Orthogonal Designs, Quadratic Forms and Hadamard Matrices, Lecture Notes in Pure and Applied Mathematics, vol. 43. New York and Basel: Marcel Dekker, 1979.

[29] J. Radon, "Lineare scharen orthogonaler matrizen," in *Abhandlungen aus dem Mathematischen Seminar der Hamburgishen Universit¨at*, vol. I.pp.1–14,1922.

[30] Jia Hou, Moon Ho Lee and Ju Yong Park " *Matrices Analysis of Quasi-Orthogonal Space-Time Block Codes " ieee communications letters, vol. 7, no. 8, august 2003 385*

[31] O. Tirkkonen, A. Boariu, and A. Hottinen, "Minimal nonorthogonality rate 1 space-time blok code for 3+ Tx antennas," in *Proc IEEE 6th Int Symp. Spread-Spectrum Techniques and Applications (ISSSTA 2000),pp*, 429–432.

[32] D˜ung Ngo.c Đào and Chintha Tellambura, "A General Method to Decode ABBA Quasi-Orthogonal Space-Time Block Codes*" IEEE Communiation Letters*, vol. 10, Octb 2006.

[33] V. Tarokh, H. Jafarkhani, and A. R. Calderbank, "Space-time block codes for high data rate wireless communication," *IEEE Trans. Inform. Theory*, vol. 44, pp. 744–765, Mar 1999.

[34] M.H. Lee, "A new reversr jacket transform and its fast algorithm," *IEEE Trans. Commun.*, vol. 47, pp. 39-47, Jan. 2000.

Author's Profile

SANDEEP KUMAR SINGH

He received his Bachlor of Technology degree in Electronics and Communication Engineering from Gautam Buddh Technical University, LUCKNOW in 2010 with Honors .He is currently pursuing Masters of Engineering degree in Electronics and Telecommunication from S.G.S.I.T.S. Indore, India.

ANJANA JAIN

She is working as ASSOCIATE PROFESSOR in SGSITS indore. She received Bachlor of Engineering in 1989 in Electronics and Telecoms from MACT Bhopal, M.P., INDIA, with Honors and masters of engineering in 1996 in Electrical Engineering from S.G.S.I.T.S., Indore, M.P., India with Honours, having Work Experience of 20 years of teaching.

ANURAG SHRIVASTAV

He is working as ASSISTANT PROFESSOR in SGSITS Indore.He received Bachlor of Engineering in Electronics and Telecoms from SVITS INDORE M.P., INDIA and masters of technology In Communication and Signal Processingfrom IIT BOMBAYIndia.