Mrs. Ranjana kumari, Mr. Rajesh Mehra /International Journal of Engineering Research and Applications (IJERA) ISSN: 2248-9622 www.ijera.com
Vol. 3, Issue 1, January -February 2013, pp.1838-1844

Performance Evolution of Improved QOSTBC in Wireless Communication System

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ABSTRACT

In this paper, a block code technique is proposed to increase the data rate and to reduce the symbol error rate for the wireless communication. The designed space time block code (STBC) is compared with golden code 2x2, silver code 2x2. STBC is used to realize the diversity gain and provide the remarkable performance in wireless communication systems using MIMO. STBC is based on improved Quasi orthogonal space time block codes (QOSTBC). Quasi orthogonal space time block codes provide higher symbol transmission rates at the expense of losing the diversity gain which provide partial diversity. The symbol error rate is to be analyzed by increasing the number of receiver antennas in power of 2 taking transmitter antenna as '2'. Other part of this work evaluate the performance of improved QOSTBC at 1, 1/2, 3/4 code rate. The proposed code reduce SER 60%.The proposed code has been designed and simulated using Matlab 7.10.

Keywords – **Cyclic division algebra , Space time coding, symbol error rate, Golden Code , Silver code, Quasi-orthogonal code(QOSTBC), sphere decoding**

I Introduction

There has been a phenomenal increase in consumers' as well as manufacturers' interest in wireless communications from the past few years, which Provide the advantages of wide area coverage without wires, allowing mobility while communicating .These are advantages of wireless communication technology. The wireless communications services are being developed beyond the success of the established technologies such as mobile telephony, a wide range of internet facilities and multimedia contents. but due to the destructive superposition of multiple received signals in a multipath propagation environment, the wireless channel suffers from random signal attenuation and phase distortion, a phenomenon is called *fading*. To combat fading and utilize the capacity of wireless channel to a higher limit, we use of multiple transmitting and/or receiving antennas. This is called Multiple-input multiple-output (MIMO) concept, has recently been proposed. The performance of the wireless communication systems can be increased by using multiple transmit and receive antennas. The goal of the multiple input and multiple output is higher data rate and higher performance. Theoretic capacity of MIMO increase with smaller number of transmitter and receiver[1]

1.1 Diversity Techniques

Diversity techniques can be used to improve system performance in fading channels. Instead of transmitting and receiving the desired signal through one channel, we obtain L copies of the desired signal through M different channels. The idea is that while some copies may undergo deep fades, others may not. We might still be able to obtain enough energy to make the correct decision on the transmitted symbol. There are several different kinds of diversity which are commonly employed in wireless communication systems [2],[3],[4]:

1.1.2 ***Temporal Diversity:*** In this scheme, channel coding in conjunction with time interleaving is used. Thus replicas of the transmitted signal are provided to the receiver in the form of redundancy in the temporal domain.

1.1.3 ***Frequency Diversity****:* In this scheme, the signals that are transmitted on different frequencies tend to experience different fading effects is exploited. Thus replicas of the transmitted signal are provided to the receiver in the form of redundancy in the frequency domain.

1.1.4 ***Spatial Diversity:*** In this scheme, spatially separated antennas are used to provide diversity in the spatial domain. Diversity combining technique is then used to select or combine the signals that have been transmitted or received on different antennas. spatial diversity into the following three configurations:

Single Input Multiple Output **(SIMO):** When there are single transmit antenna but multiple receive antennas, i.e. *receive diversity*.

***Multiple Input Single Output* (MISO):** When there are multiple transmit antennas but one receive antenna, i.e. *transmit diversity*.

***Multiple Input Multiple Output* (MIMO):** When there are multiple transmit antennas and multiple receive antennas, i.e. both transmit and receive diversity are used.

1.2 Space time coding

When we use the multiple transmit antennas and receiving antennas then we introduce the space time coding. This techniques is used in digital communication in the wireless environment. The space-time coding is a promising way to realize the gain in the wireless communications system using MIMO. The advantage of space time coding is , able to provide the multipath propagation in benefits of multiple antennas ,to increase the data rate and reliability of wireless communication.

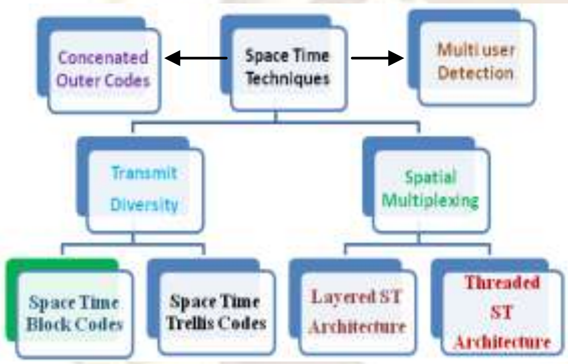

Fig1. Classification of Space time techniques

Fig.1 shows several type of space time coding techniques.Space time technique classified in to techniques on the basis of diversity and spatial multiplexing.Transmit diversity provides space time block codes and space time trellis codes and saptial multiplexing provides layered ST architecture and threaded ST architechture.

II SPACE TIME BLOCK CODE (STBC)

Space time block code can be represented by matrix. In which each row can be represented by the time slots and each column represent the transmission of one antenna over each time slot.

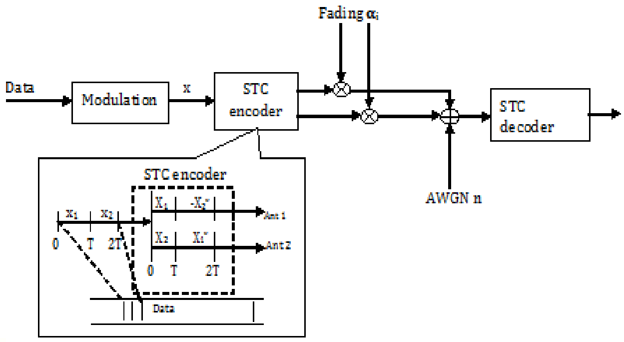

Fig. 2 Original Scheme for code generation

2.1 Transmission Model

In Fig 2 show the original scheme for code generation .Original data is applied to modulator to modulate the signal. After modulation these data converted into the symbol .Symbol is represented by the S_i. Transmission model has STC encoder is connected to antennas to transmit these block. Theses transmitted stream of the data passes through fading path .By using STC encoder can generate the multiple copies of the data .these multiple copies has uncorrelated attenuation .multiple copies is received by the multiple receive antenna, by the linear processing

2.2 ENCODING AND DECODING ALGORITHM OF SPACE TIME BLOCK CODE

Equation (1) represent the Encoder matrix . S_{ij} transmitted
symbol over the time slots.

Transmit Antennas →

Time Slots ↓

$$\begin{bmatrix} S_{11} & S_{12} \cdots\cdots & S_{1nT} \\ S_{21} & S_{22} \cdots\cdots & S_{2nT} \\ \vdots & \vdots & \vdots \\ S_{T1} & S_{T2} \cdots\cdots & S_{TnT} \end{bmatrix} \quad (1)$$

Vahid Tarokh et. al in [5] were proposed the code rate of an STBC measures how many symbols per time slot it transmits on average over the course of one block. If a block encodes k symbols, the code-rate in Equation (2)

$$R = \frac{k}{T} \quad (2)$$

In order to consider a decoding method, a model of the wireless communications system is needed. At time t, the signal r_t^j received at antenna j is:

$$r_t^j = \sum_{i=1}^{nT} \alpha_{ij} s_t^j + n_t^j \quad (3)$$

In equation (2) α_{ij} is the path gain from transmit antenna i to receiver antenna j. s_t^j is the transmitted signal from transmitter antenna. And n_t^j is the additive white Gaussian noise.

$$R_i = \sum_{t=1}^{nT}\sum_{j=1}^{nR} r_t^j \alpha_{\epsilon t(i)j}\delta_t(i) \quad (4)$$

vahid Tarokh et al. in [5] developed the maximum-likelihood detection rule is the form of the decision variable in equation (4). In this equation $\delta_k(i)$ is the sign of transmitted signal in the row of the coding matrix, then decide on constellation symbol s_i that satisfies in Equation(5) with A the constellation alphabet. this is a simple, linear decoding scheme that provides maximal diversity.

$$S_i = \arg\min_{s\epsilon A}\left(|R_i - S|^2 + \left(-1 + \sum_{k,l}|\alpha_{kl}|^2\right)|s|^2\right) \quad (5)$$

III. CYCLIC DIVISION ALGEBRA (CDA)

Cyclic division algebra is mathematical tool to design the space time coding, which give the best way of build a fully diverse space time code. CDA used to increase the throughput of the code by using algebras over number field. The number field is used to encoding of QAM and HEX constellations. Then family algebras is called cyclic algebra which built over number field[6]. When number of transmit Antenna n and n x n space time code word, this type of code words send the n^2 information symbol encoded into signals. Space time coding has the most important property which is the non vanishing determinants. The ring of integer of number of field can be used to build the algebra lattice. By using of the lattice structure can control the transmitted energy when encoding the space time codes.

In Fig.3 shown the algebra structure of cyclic division algebra .Number field is the set of rational number Q, number can check this is field or not. Let element 'i' .when Q is linear combination 'i' the this is Q (i). This is called field extension of Q. This is field extension of Q is called Number field.

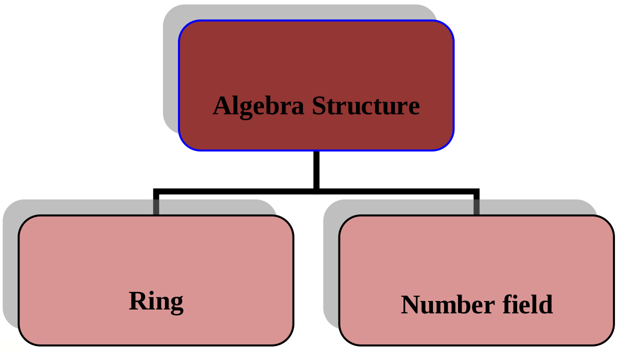

Fig3.Algebra structure of cyclic division algebra

To explain the cyclic algebra let us assume a Galois extension of degree of x, which is Galois group

$$G = Gal[L/x] \quad (6)$$

Equation (6) is cyclic with generator 'g' which take the element .this the on commutative algebra denoted by B

$$B=\{L/x, g, y\} \quad (7)$$

$$B=L\oplus eL\oplus\text{-------------}e^{n-1} \quad (8)$$

$\oplus$ is the direct sum. Equation (8) shows the cyclic algebra [6].

IV.CDA BASED SPACE TIME BLOCK CODES

4.1 Alamouti Code

Alamouti code is proposed in 1998[7]. This is first space time block code which is based on Cyclic division algebra that provide the full diversity at full rate for the two transmitter[8]. According to Alamouti, this code uses M-ary modulation scheme is used to modulate the information bits. In encoding operation space time encoder encode the symbol $S_1$and S_2. $S_1$and S_2 symbol are transmitted through the two transmits antenna over the time slots. The code matrix shown in equation (9)

$$\begin{matrix} & Tx1 & Tx2 \end{matrix}$$
$$S = \begin{bmatrix} S1 & S2 \\ -S2* & -S1* \end{bmatrix} \quad (9)$$

In the equation (9) shows this is the matrix which has the rows and columns. At first time slot t1 two symbols S_1 and S_2 transmitted by Tx1 and Tx2 .At the second time slot t2 $-S_2^*$ and $-S_1^*$ are transmitted by two transmit antenna T1 and T2.equation (9) shows the two rows and two columns are orthogonal then encoder matrix has orthogonal property. and a low-complexity by using ML decoder.

4.2 Golden Code

J.C Belfire et. Al. [9] proposed the golden code for the a 2x2 full rate space time block code with non determinants in 2005.Golden code generated from division algebra which is full rate and fully diverse 2x2 code. This is design for integer lattice structure. Golden code provides high ML decoding complexity of order of M^4. M is size of constellation. Laura Luzzi et.al. [10] Proposed the Golden space time block coded modulation for 2x2 multiple input and output space time code for slow fading channels. Also proposed the general structure of encoder which shown in Fig 4.

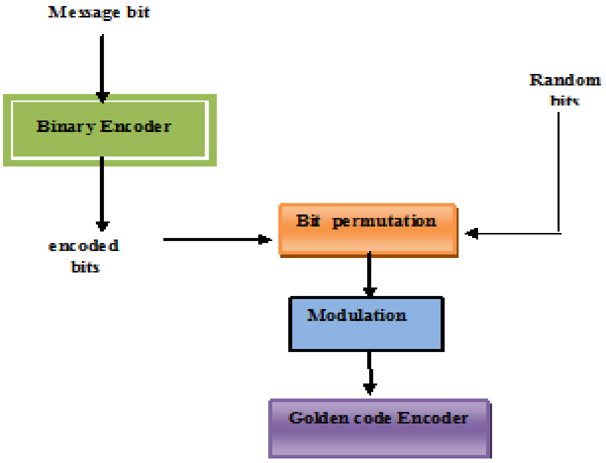

Fig 4. The Structure of encoder

The structure of encoder following.

i. The information message bits is divided inti two parts. First data block of bits is encoded by the linear block code with generator matrix. Second block is uncoded.

ii. These two binary bit sequences are mixed up in the rearrange in uncoded bit sequence. This binary sequence is mixed up and rearranged by Bit permutation block. The output of Bit permutation block applied to the modulation block. There are four vector modulated by QAM constellation.

iii. Finally, each of vectors (a, b, c, d) is encoded by golden code encoder. Code word of golden code is shown in equation (10)

$$X = \frac{1}{\sqrt{5}}\begin{bmatrix} \alpha(a+b\theta) & \alpha(c+d\theta) \\ \bar{\alpha} i(c+d\bar{\theta}) & \bar{\alpha}(a+b\bar{\theta}) \end{bmatrix} \quad (10)$$

where

$$\theta = \frac{1+\sqrt{5}}{2}, \ \bar{\theta} = 1-\theta \quad (11)$$

4.3 Silver Code as cyclic division algebra

C. Hollanti, et al proposed in [11] a 2x2 perfect space time block code, which is totally based on cyclic division algebra based , tells how can be constructed cyclic algebra based code. Due to this property, code provide the minimum determinant, also proved Minimum determinant is the diversity multiplexing tradeoff [11].

Silver code is represented by the 'S' which is sum of two alamouti matrix with matrix 'v' shown in equation (12)

$$S = \{X = X_A + VX_B\} \quad (12)$$

Where

$$X_A = X_A(x_1, x_2) = \begin{bmatrix} x_1 & -x_2^* \\ x_2 & x_1^* \end{bmatrix}$$

And

$$X_B = X_B(Z_1, Z_2) = \begin{bmatrix} Z_1 & -Z_2^* \\ Z_2 & Z_1^* \end{bmatrix}$$

X_A and X_B are Alamouti codes . .

$V = \begin{bmatrix} 1 & 0 \\ 0 & -1 \end{bmatrix}$ is twisting matrix. By putting the value of x_3 , x_4 in equation (13). We get the Z_1,Z_2.

$$\begin{bmatrix} Z_1 \\ Z_2 \end{bmatrix} = {}^{1}/_{\sqrt{7}} \begin{pmatrix} 1+i & -1+2i \\ 1+2i & 1-i \end{pmatrix} \begin{bmatrix} x_3 \\ x_4 \end{bmatrix} \quad (13)$$

By use of sphere decoder silver code provide minimum determinant ${}^{1}/_{\sqrt{7}}$ and ML decoding complexity is $4M^2$.

4.4 Quasi orthogonal STBC code (QOSTBC)

This type of the code has been proposed by the [5] which has orthogonal property of code .This code has been designed by orthogonal property. Orthogonal code is in the form of Transmission matrix with orthogonal columns. It also shown that how the transmit symbols can be separated by decoding process at receiver [12]. This QOSTBC designed code provides the transmission matrixes which do not separate transmitted symbols at the decoder by each other. QOSTBC is a transmission matrix which has the rows and columns. These columns are divided in groups. But each group within columns are not orthogonal each other. So we called the quasi orthogonal STBC. The pairs of transmitted symbol can be decoded by using quasi orthogonal space time block code. This type of structure provides the higher transmission rate while compromising full diversity.

Orthogonality of the symbols by using Alamouti [7] proposed first space time transmission matrix.

$$B_{1,2} = \begin{bmatrix} T_1 & T_2 \\ -T_2^* & T_1^* \end{bmatrix} \quad (14)$$

Where $B_{1,2}$ indicate T_1 and T_2 existing matrix. Then based on Alamouti orthogonal matrix and Jafarkhani [12] gave QOSTBC for the four transmit antennas for improving transmit diversity as

$$C_{AJ} = \begin{bmatrix} B_{1,2} & B_{3,4} \\ -B_{3,4}^* & B_{1,2}^* \end{bmatrix} = \begin{bmatrix} T_1 & T_2 & T_3 & T_4 \\ -T_2^* & T_1^* & -T_4^* & T_3^* \\ -T_3^* & -T_4^* & T_1^* & T_2^* \\ T_4 & -T_3 & -T_2 & T_1 \end{bmatrix} \quad (15)$$

In equation (15) $B_{1,2}$ and $B_{3,4}$ are orthogonal code which are based Alamouti code. Other code from Jafrakhani [12] scheme TBH case [13] . ABBA code is also class of QSTBC codes which proposed to increase the rate of orthogonal space-time block codes (OSTBC)[14].

$$C_{JA} = \begin{bmatrix} B_{1,2} & B_{3,4} \\ B_{3,4} & B_{1,2} \end{bmatrix} = \begin{bmatrix} T_1 & T_2 & T_3 & T_4 \\ -T_2^* & T_1^* & -T_4^* & T_3^* \\ T_3 & T_4 & T_1 & T_2 \\ -T_4^* & T_3^* & -T_2^* & T_1^* \end{bmatrix} \quad (16)$$

4.5 Proposed Code

We have proposed a new improved space time block code. .New STBC is based on quasi orthogonal space time block code (QOSTBC) which provides better performance from other existing STBC. By use of ML decoder, we analyze the performance at the code rate 1, 1/2, 3/4 and proposed code is compared with golden code and silver code. Channel is to be assumed Additive white Gaussian noise channel. The proposed STBC is given by

$$C_{JP} = \begin{bmatrix} T_1 & T_2 & T_3 & T_4 \\ -T_2^* & T_1^* & -T_4^* & T_3^* \\ -T_3 & -T_4 & T_1 & T_2 \\ T_4^* & -T_3^* & -T_2^* & T_1^* \end{bmatrix} \quad (17)$$

V. PROPOSED CODE SIMULATION AND COMPARISION WITH OTHER CODE

Firstly we compare golden code and silver code with improved QOSTBC at number of receiver in power of 2.Symbol error rate can be reduced by increasing the receiver antenna in power of two as shown in Fig 5.which may or may not be helpful in wireless communication it depend on the applications. We see designed code for 2x2, 2x4, 2x8, 2x16 performances which is better than other STBC. Next results we show in Fig 6.Proposed code is compared with golden code and silver code at the different code rate 1, 1/2 , 3/4 .

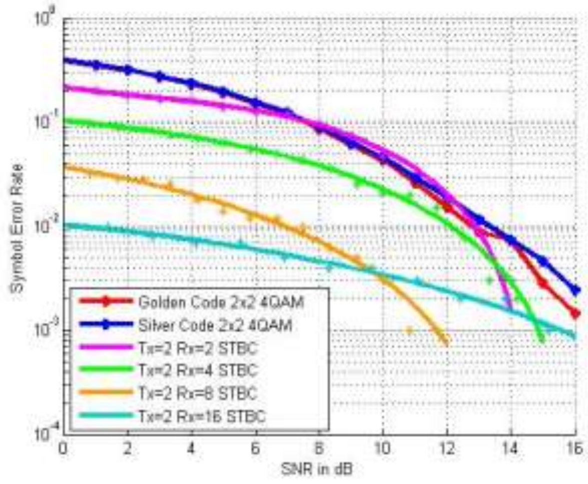

Fig. 5 SER performance comparisons of different STBC under $n_r \geq n_t$ & QAM modulation techniques

.Theses analysis of proposed code give better to other code .all parameters of proposed code are compared with Golden code and silver code which shown in Table I.

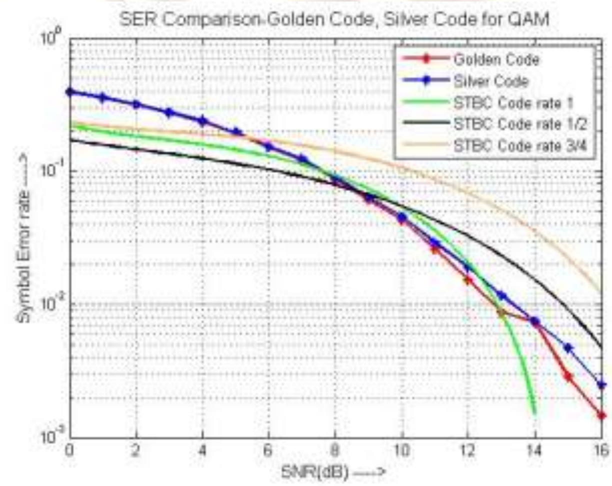

Fig. 6 SER performance comparisons of different STBC under code rate 1,1/2,3/4 & QAM modulation techniques

TABLE I .

S.No.	4 QAM Modulation Techniques. & SNR range(1-16)in dB				
	Code Name	No. of Tx	No. of Rx	Symbol error rate	% of SER from Golden code
1	Golden Code	2	2	0.3917	
2	Silver Code	2	2	0.3919	
3	Proposed Coded at code rate'1'	2	2	0.217	45%
	code rate'1/2'	2	2	0.173	60%
	code rate'3/4'	2	2	0.229	41%

VI CONCLUSION

Proposed code has been analyzed by increasing the receiver antennas and by changing the code rate. We conclude that symbol error rate performance can be reduced by increasing the receiver antenna and changing the code rate. Simulation result shows that proposed code also makes a significant contribution to wireless system by reducing symbol error rate. This proposed code is suitable for future evaluation of Wi-Max systems towards higher data rate and reduced error performance.

ACKNOWLEDGEMENT

The authors would like to thank anonymous reviewers for helpful comments to improve the presentation of the paper.

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