SPACE TIME BLOCK CODES FORELEVEN AND TWELVE TRANSMIT ANTENNAS WITH FULL CODE RATE

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Abstract— Alamouti Proposed Orthogonal STBCS for two transmit antennas with code rate one. Tarkoh investigated for three to eight transmit antennas with code rate is ½. Jafarkhni proposed for non orthogonal STBCS four transmit antennas with code rate is one.. Tarokh, Jafarkhani, and Calderbank[3] gave the transmitting antennas code rate- ½ for nine transmit antennas code has delay 32. This paper intends new matrix GCOD Space time block codes for eleven and twelve transmit antennas which can send 16 information symbols in a block of 16 channel uses and hence have code rate 16/16=1

Keywords— Diversity, (generalized) complex orthogonal designs, space –time block codes

I. COMPLEX ORTHOGONAL DESIGNS

Currently, MIMO technology has attracted great consideration because of its great advantages. MIMO considered that the capacity of wireless channel can be significantly increased by the use of multiple antennas at transmitter and receiver and mitigating the multi channel fading[1]. One of the main element in MIMO system, called space-time block coding(STBC), can improve the reliability of MIMO system. A noteworthy coding scheme named Alamouti code two transmit practical diversity was invented in 1998 for MIMO system, which has full transmitted diversity and can be decoded by decoded maximum-likelihood method due to its orthogonality [2]. Yet, the code rate of an orthogonal STBC (OSTBC) is upper bounded by 3/4 transmitted symbols per channel use for more than two transmit antennas [3].

Definition 1: A generalized complex orthogonal design (GCOD) in variables $x_1, x_2, \ldots, x_k$ is a p × n matrix G such that:

- the entries of G are complex linear combinations of $x_1, x_2, \ldots, x_k$ and their complex conjugates $x_1^*, x_2^*, \ldots, x_k^*$
- $G^H G = D$, where G^H is the complex conjugate and transpose of G, and D is an n×n diagonal matrix with the (i, i) th diagonal element of the form $l_{i,1}|x_1|^2 + l_{i,2}|x_2|^2 + l_{i,3}|x_3|^2 + \ldots\ldots + l_{i,k}|x_k|^2$ where all the coefficients $l_{i,1}, l_{i,2}, l_{i,3}, \ldots\ldots, l_{i,k}$ are strictly positive numbers.

The rate of G is defined as R = k/p. If $G^H G = \left(|x_1|^2 + |x_2|^2 + \ldots\ldots + |x_k|^2\right) I_{nxn}$ Then G is called a complex orthogonal design (COD).

The first space–time block code from complex orthogonal design was proposed in Alamouti for two transmit antennas. It is the following 2 × 2 COD in variables x_1 and x_2

$$G_2 = \begin{pmatrix} x_1 & x_2 \\ -x_2^* & x_1^* \end{pmatrix}$$

For n = 3 and n = 4 transmit antennas , there are complex orthogonal designs of rate R = 3/4for example,

$$G_3 = \begin{pmatrix} x_1 & x_2 & x_3 \\ -x^*_2 & x^*_1 & 0 \\ x^*_3 & 0 & -x^*_1 \\ 0 & x^*_3 & -x^*_2 \end{pmatrix}$$

$$G_4 = \begin{pmatrix} x_1 & x_2 & x_3 & 0 \\ -x^*_2 & x^*_1 & 0 & x_3 \\ x^*_3 & 0 & -x^*_1 & x_2 \\ 0 & x^*_3 & -x^*_2 & -x_1 \end{pmatrix}$$

The theory of space-time block codes was further developed by Weifen Su and Xian-Gen Xia[5] . They defined space time block codes in terms of orthogonal code matrices. The properties of these matrices ensure rate 7/11 and 3/5 for 5 and 6 transmit antenna.

The theory of space-time block codes was further developed by M.A.Islam Jewel, M.Rahman. They defined space time block codes in terms of orthogonal code matrices. The properties of these matrices ensure full rate for four transmit antenna. So the new matrix 4 x 4 is given by

$$G_4^{new} = \begin{bmatrix} x_1 & x_2 & x_3 & x_4^* \\ -x_2^* & x_1^* & -x_4 & x_3^* \\ -x_3^* & x_4 & x_1^* & -x_2^* \\ -x_4^* & -x_3 & x_2 & x_1 \end{bmatrix}$$

II Existed *GCODs of Rates 5/11*,6/14 , 8/15 and 5/13 *for* n=5 n=6 *Transmit Antennas*

The existing five transmit antennas which can send 5 information symbols in a block of 11 channel uses and hence have code rate 5/11 and matrix is expressed [6]as

$$G5 = \begin{pmatrix} z1 & 0 & 0 & 0 & z2 \\ 0 & z1 & 0 & 0 & z3 \\ 0 & 0 & z1 & 0 & z4 \\ 0 & 0 & 0 & z1 & z5 \\ -z2* & -z3* & -z4* & -z5* & z1* \\ -z3 & z2 & 0 & 0 & 0 \\ -z4 & 0 & z2 & 0 & 0 \\ -z5 & 0 & 0 & z2 & 0 \\ 0 & -z4 & z3 & 0 & 0 \\ 0 & -z5 & 0 & z3 & 0 \\ 0 & 0 & -z5 & z4 & 0 \end{pmatrix}$$

The existing six transmit antennas which can send 6 information symbols in a block of 14 channel uses and hence have code rate 6/14 and matrix is expressed as

$$G6 = \begin{bmatrix} x^*_1 & x^*_6 & x^*_5 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & -x_1 & x_6 \\ 0 & -x^*_4 & x^*_3 & -x^*_1 & 0 & 0 \\ 0 & 0 & 0 & 0 & x^*_6 & x^*_1 \\ x_2 & x_3 & x_4 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & -x^*_2 & x^*_4 \\ 0 & 0 & 0 & 0 & -x^*_3 & x^*_5 \\ -x^*_3 & x^*_2 & 0 & -x^*_5 & 0 & 0 \\ 0 & 0 & 0 & 0 & x_5 & x_3 \\ x^*_4 & 0 & -x^*_2 & -x^*_6 & 0 & 0 \\ 0 & 0 & 0 & 0 & x_4 & x_2 \\ 0 & x_5 & -x_6 & x_2 & 0 & 0 \\ x_5 & 0 & -x_1 & -x_3 & 0 & 0 \\ x_6 & -x_1 & 0 & x_4 & 0 & 0 \end{bmatrix}$$

The existing six transmit antennas which can send 8 information symbols in a block of 15 channel uses and hence have code rate 8/15 and matrix is expressed as

$$G6=\begin{bmatrix}
x_1^* & x_6^* & 0 & x_3^* & 0 & 0\\
0 & 0 & x_3 & 0 & -x_1 & 0\\
-x_2^* & -x_5^* & 0 & 0 & x_4 & x_3^*\\
x_3 & 0 & 0 & -x_1 & 0 & x_2\\
0 & x_7^* & x_4 & -x_2^* & 0 & -x_1^*\\
0 & 0 & -x_5^* & 0 & -x_7 & 0\\
x_4^* & 0 & 0 & x_8^* & x_6 & 0\\
0 & -x_4^* & x_7^* & 0 & -x_5 & x_8^*\\
-x_5 & x_2 & 0 & x_7 & 0 & x_2\\
x_6 & -x_1 & x_8 & 0 & 0 & -x_7\\
0 & x_3 & 0 & -x_6 & x_8^* & x_5\\
0 & 0 & -x_6^* & 0 & x_2 & 0\\
0 & -x_8 & x_1^* & 0 & x_3^* & -x_4\\
-x_7^* & 0 & 0 & -x_5^* & 0 & -x_6^*\\
-x_8 & 0 & x_2^* & x_4 & 0 & 0
\end{bmatrix}$$

Where rate R = 8/15 = 0.62

$$G_8=\begin{pmatrix}
x_1 & x_2 & x_3 & x_4 & x_5 & x_6 & x_7 & x_8\\
-x_2 & x_1 & x_4 & -x_3 & x_6 & -x_5 & -x_8 & x_7\\
-x_3 & -x_4 & x_1 & x_2 & x_7 & x_8 & -x_5 & -x_6\\
-x_4 & x_3 & -x_2 & x_1 & x_8 & -x_7 & x_6 & -x_5\\
-x_5 & -x_6 & -x_7 & -x_8 & x_1 & x_2 & x_3 & x_4\\
-x_6 & x_5 & -x_8 & x_7 & -x_2 & x_1 & -x_4 & x_3\\
-x_7 & x_8 & x_5 & -x_6 & -x_3 & x_4 & x_1 & -x_2\\
-x_8 & -x_7 & x_6 & x_5 & -x_4 & -x_3 & x_2 & x_1\\
x_1^* & x_2^* & x_3^* & x_4^* & x_5^* & x_6^* & x_7^* & x_8^*\\
-x_2^* & x_1^* & x_4^* & -x_3^* & x_6^* & -x_5^* & -x_8^* & x_7^*\\
-x_3^* & -x_4^* & x_1^* & x_2^* & x_7^* & x_8^* & -x_5^* & -x_6^*\\
-x_4^* & x_3^* & -x_2^* & x_1^* & x_8^* & -x_7^* & x_6^* & -x_5^*\\
-x_5^* & -x_6^* & -x_7^* & -x_8^* & x_1^* & x_2^* & x_3^* & x_4^*\\
-x_6^* & x_5^* & -x_8^* & x_7^* & -x_2^* & x_1^* & -x_4^* & x_3^*\\
-x_7^* & x_8^* & x_5^* & -x_6^* & -x_3^* & x_4^* & x_1^* & -x_2^*\\
-x_8^* & -x_7^* & x_6^* & x_5^* & -x_4^* & -x_3^* & x_2^* & x_1^*
\end{pmatrix}$$

where the block length p = 16. For n (n = 5, 6,7, 8) transmit antennas. By deleting columns 7,8 we obtained the six transmit antennas Space time block.

III Existing GCODs Space time block codes for n = 11 ,12 Transmit Antennas

Tarokh, Jafarkhani, and Calderbank[3] gave the transmitting antennas code rate- ½ for nine transmit antennas code has delay 32

IV New GCODs Space time block codes for n = 11 ,12 Transmit Antennas

The Proposed Eleven transmit antennas which can send 16 information symbols in a block of 16 channel uses and hence have code rate 16/16=1 and matrix is expressed as

$$\begin{bmatrix}
x_1 & x_2 & x_3 & \dot{x}_4 & x_5 & x_6 & x_7 & \dot{x}_8 & x_9 & x_{10} & x_{11}\\
-\dot{x}_2 & \dot{x}_1 & -\dot{x}_4 & \dot{x}_3 & -\dot{x}_6 & \dot{x}_5 & -x_8 & \dot{x}_7 & -\dot{x}_{10} & \dot{x}_9 & -x_{12}\\
-\dot{x}_3 & x_4 & \dot{x}_1 & -x_2 & -\dot{x}_7 & x_8 & \dot{x}_5 & -\dot{x}_6 & -\dot{x}_{11} & x_{12} & \dot{x}_9\\
-\dot{x}_4 & -x_3 & x_2 & x_1 & -\dot{x}_8 & -x_7 & x_6 & x_5 & -\dot{x}_{12} & -x_{11} & x_{10}\\
x_5 & x_6 & x_7 & \dot{x}_8 & x_1 & x_2 & x_3 & x_4 & x_{13} & x_{14} & x_{15}\\
-\dot{x}_6 & \dot{x}_5 & -x_8 & \dot{x}_7 & -\dot{x}_2 & \dot{x}_1 & -x_4 & -\dot{x}_3 & -\dot{x}_{14} & \dot{x}_{13} & -x_{16}\\
-\dot{x}_7 & x_8 & \dot{x}_5 & -\dot{x}_6 & -\dot{x}_3 & x_4 & \dot{x}_1 & -\dot{x}_2 & -\dot{x}_{15} & x_{16} & \dot{x}_{13}\\
-\dot{x}_8 & -x_7 & x_6 & x_5 & -\dot{x}_4 & -x_3 & x_2 & x_1 & -\dot{x}_{16} & -x_{15} & x_{14}\\
-x_9 & x_{10} & x_{11} & \dot{x}_{12} & x_{13} & x_{14} & x_{15} & \dot{x}_{16} & x_1 & x_2 & x_3\\
-\dot{x}_{10} & \dot{x}_9 & -x_{12} & \dot{x}_{11} & -\dot{x}_{14} & \dot{x}_{13} & -x_{16} & \dot{x}_{15} & -\dot{x}_2 & \dot{x}_1 & -x_4\\
-\dot{x}_{11} & x_{12} & \dot{x}_9 & -\dot{x}_{10} & -\dot{x}_{15} & x_{16} & \dot{x}_{13} & -\dot{x}_{14} & -\dot{x}_3 & x_{14} & \dot{x}_1\\
-\dot{x}_{12} & -x_{11} & x_{10} & x_9 & -\dot{x}_{16} & -x_{15} & x_{14} & x_{13} & -\dot{x}_4 & -x_3 & x_2\\
x_{13} & x_{14} & x_{15} & \dot{x}_{16} & x_9 & x_{10} & x_{11} & \dot{x}_{12} & x_5 & x_6 & x_7\\
-\dot{x}_{14} & \dot{x}_{13} & -x_{16} & \dot{x}_{15} & -\dot{x}_{10} & \dot{x}_9 & -x_{12} & \dot{x}_{11} & -\dot{x}_6 & \dot{x}_5 & -x_8\\
-\dot{x}_{15} & x_{16} & \dot{x}_{13} & -\dot{x}_{14} & -\dot{x}_{11} & x_{12} & \dot{x}_9 & -\dot{x}_{11} & -\dot{x}_7 & x_8 & \dot{x}_5\\
-\dot{x}_{16} & -x_{15} & x_{14} & x_{13} & -\dot{x}_{12} & -x_{11} & x_{10} & x_9 & -\dot{x}_8 & -x_7 & x_6
\end{bmatrix}$$

Next Proposed generalized complex orthogonal space-time block code (COSTBC) design of code rate 1 for twelve transmit antenna Where the block length with codeword p=16, and the carriers information symbols k=16.Thus one can get $R=k/p=16/16=1$. So the new matrix 16*12 is given by.

$$\begin{bmatrix}
x_1 & x_2 & x_3 & \dot{x}_4 & x_5 & x_6 & x_7 & \dot{x}_8 & x_9 & x_{10} & x_{11} & x_{12}\\
-\dot{x}_2 & \dot{x}_1 & -\dot{x}_4 & \dot{x}_3 & -\dot{x}_6 & \dot{x}_5 & -x_8 & \dot{x}_7 & -\dot{x}_{10} & \dot{x}_9 & -x_{12} & \dot{x}_{11}\\
-\dot{x}_3 & x_4 & \dot{x}_1 & -x_2 & -\dot{x}_7 & x_8 & \dot{x}_5 & -\dot{x}_6 & -\dot{x}_{11} & x_{12} & \dot{x}_9 & -\dot{x}_{10}\\
-\dot{x}_4 & -x_3 & x_2 & x_1 & -\dot{x}_8 & -x_7 & x_6 & x_5 & -\dot{x}_{12} & -x_{11} & x_{10} & x_9\\
x_5 & x_6 & x_7 & \dot{x}_8 & x_1 & x_2 & x_3 & x_4 & x_{13} & x_{14} & x_{15} & \dot{x}_{16}\\
-\dot{x}_6 & \dot{x}_5 & -x_8 & \dot{x}_7 & -\dot{x}_2 & \dot{x}_1 & -x_4 & -\dot{x}_3 & -\dot{x}_{14} & \dot{x}_{13} & -x_{16} & \dot{x}_{15}\\
-\dot{x}_7 & x_8 & \dot{x}_5 & -\dot{x}_6 & -\dot{x}_3 & x_4 & \dot{x}_1 & -\dot{x}_2 & -\dot{x}_{15} & x_{16} & \dot{x}_{13} & -\dot{x}_{14}\\
-\dot{x}_8 & -x_7 & x_6 & x_5 & -\dot{x}_4 & -x_3 & x_2 & x_1 & -\dot{x}_{16} & -x_{15} & x_{14} & x_{13}\\
-x_9 & x_{10} & x_{11} & \dot{x}_{12} & x_{13} & x_{14} & x_{15} & \dot{x}_{16} & x_1 & x_2 & x_3 & \dot{x}_4\\
-\dot{x}_{10} & \dot{x}_9 & -x_{12} & \dot{x}_{11} & -\dot{x}_{14} & \dot{x}_{13} & -x_{16} & \dot{x}_{15} & -\dot{x}_2 & \dot{x}_1 & -x_4 & \dot{x}_3\\
-\dot{x}_{11} & x_{12} & \dot{x}_9 & -\dot{x}_{10} & -\dot{x}_{15} & x_{16} & \dot{x}_{13} & -\dot{x}_{14} & -\dot{x}_3 & x_{14} & \dot{x}_1 & -\dot{x}_2\\
-\dot{x}_{12} & -x_{11} & x_{10} & x_9 & -\dot{x}_{16} & -x_{15} & x_{14} & x_{13} & -\dot{x}_4 & -x_3 & x_2 & x_1\\
x_{13} & x_{14} & x_{15} & \dot{x}_{16} & x_9 & x_{10} & x_{11} & \dot{x}_{12} & x_5 & x_6 & x_7 & \dot{x}_8\\
-\dot{x}_{14} & \dot{x}_{13} & -x_{16} & \dot{x}_{15} & -\dot{x}_{10} & \dot{x}_9 & -x_{12} & \dot{x}_{11} & -\dot{x}_6 & \dot{x}_5 & -x_8 & x_7\\
-\dot{x}_{15} & x_{16} & \dot{x}_{13} & -\dot{x}_{14} & -\dot{x}_{11} & x_{12} & \dot{x}_9 & -\dot{x}_{11} & -\dot{x}_7 & x_8 & \dot{x}_5 & -\dot{x}_6\\
-\dot{x}_{16} & -x_{15} & x_{14} & x_{13} & -\dot{x}_{12} & -x_{11} & x_{10} & x_9 & -\dot{x}_8 & -x_7 & x_6 & x_5
\end{bmatrix}$$

V. **Conclusion**

In this work we have proposed *new* general complex orthogonal space-time block codes for

Eleven and Twelve Transmit Antenna with code rate one . By increasing number of transmit antennas the bit error rate decreases and hence the Performance of the Wireless Communication system increases.By Comparing above marices proposed matrix is comparmize w.r.t code rate and minimal delay.

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