**N.S.Murthy, Dr.S.Sri Gowri, Dr.B.Prabhakara Rao / International Journal of Engineering Research and Applications (IJERA) ISSN: 2248-9622 www.ijera.com**
**Vol. 2, Issue 4, July-August 2012, pp.362-364**

# Orthogonal Space-Time Block Codes for 6 Transmit Antennas in Space Time Block codes

**N.S.Murthy * Dr.S.Sri Gowri** Dr.B.Prabhakara Rao*****
* Associate Professor, ECE Dept, VR Siddhartha Engg. College,Vijayawada-7,INDIA
** Professor& HOD, ECE Dept, SRK Institute of Technology, Vijayawada,INDIA
*** Professor, ECE Dept,JNTUK,Kakinada

**Abstract –**

**Space –time block codes from orthogonal design have two advantages, namely, fast maximum – likelihood (ML) decoding and full diversity. Rate 1 real space –time codes (real orthogonal design) for multiple transmit antennas have been constructed from the real Hurwitz – Radon families, which also provides the rate ½ complex space –time codes(complex orthogonal designs) for any number of transmit antennas. Rate ¾ complex orthogonal designs (space – time codes) for three and four transmit antennas and rate 6/14 for 6 Transmit Antennas have existed in the literature In this correspondence, we present rate 8/15 generalized complex orthogonal designs for six transmit antennas with improved code rate, respectively.**

*Index Terms* – Diversity, (generalized) complex orthogonal designs, space –time block codes.

## I. INTRODUCTION

Since the pioneering work of Alamouti [1] in 1998, orthogonal design has become an effective technique for develop the space-time block codes (STBC). Its code for two transmit antennas has been incorporate as a simple and efficient transmit diversity technique in the wireless standard W-CDMA. Tarokh, Jafarkhani, and Calderbank [2] proposed space-time block coding with orthogonal designs for any numbers of transmit antennas ad the generalizations of Alamouti's scheme for two transmit antennas. The special structure of orthogonal designs guarantees that these codes achieve full diversity and have a simple maximum-likelihood decoding algorithm. In general, there are two criteria for the evaluation of a complex orthogonal designs (CODs) code

- Rate R: R=k/p, higher rate means more information carried by the code.
- Block length p: given n and R, a smaller p results less delay in decoding, and we can call it Decoding delay also.

To design "good "space-time block codes is a challenging problem. Since a space- time block code is a collection of some matrices, even for small block size and a reasonable rate, the set of a space- time block code can be significantly large and therefore, its maximum-likelihood(ML)decoding may have a high complexity. On the other hand, the performance of space – time block code depends on the diversity of the code. Therefore, a "good" space-time block code should possess two properties: i) the decoding at the receiver is reasonably fast; and ii) the diversity of the code is not small.

Let $x_1, x_2, \ldots, x_k$ be information symbols in S. The entries of the complex orthogonal design of G are formed from complex linear combinations of $x_1$, $x_1^*$ $x_2$, $x_2^*$. . . $x_k$, $x_k^*$ such that the columns of G are orthogonal to each other, where $x^*$ is the complex conjugate of $x$. The rate of the code is R = $k/p$, which means that each codeword with block length p carries k information symbols. Clearly, for a given $k$, the smallest possible block length p is k.

## II. COMPLEX ORTHOGONAL ESIGNS

We first review the concept of the (generalized) complex orthogonal design and some known designs of rate greater than or equal to 1/2[3], [4], [5]–[8].

*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 .

Tarokh, Jafarkhani, and Calderbank [3] first mentioned that the rate of space-time block codes from generalized complex orthogonal designs cannot be greater than 1, i.e., R = k/p ≤ 1. Later, it was proved in [9] that this rate must be less than 1 for more than two transmit antennas. For a fixed number of transmit antennas n and rate R, it is desired to have the block length p as small as possible. The first space–time block code from complex orthogonal design was proposed in Alamouti [3] for two transmit antennas. It is the following 2 × 2 COD in variables $x_1$ and $x_2$

$$G_2 = \begin{pmatrix} x_1 & x_2 \\ -x^*_2 & x^*_1 \end{pmatrix}$$

the rate of G2 achieves the maximum rate one.
For n = 3 and n = 4 transmit antennas, there are complex orthogonal designs of rate R = 3/4 [3],
for example, for three transmit antennas

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

for four transmit antennas, and

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

The theory of space-time block codes was further developed by Weifen Su and Xian-Gen Xia [9]. 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.

$$G6 = \begin{pmatrix}
x_1 & x_2 & x_3 & 0 & x_4 & x_8 \\
-x^*_2 & x^*_1 & 0 & x_3 & x_5 & x_9 \\
x^*_3 & 0 & -x^*_1 & x_2 & x_6 & x_{10} \\
0 & x^*_3 & -x^*_2 & -x_1 & x_7 & x_{11} \\
x^*_4 & 0 & 0 & -x^*_7 & -x^*_1 & x_{12} \\
0 & x^*_4 & 0 & x^*_6 & -x^*_2 & x_{13} \\
0 & 0 & x^*_4 & x^*_5 & -x^*_3 & x_{14} \\
0 & x^*_5 & -x^*_6 & 0 & -x_1 & x_{15} \\
x^*_5 & 0 & x^*_7 & 0 & x_2 & x_{16} \\
x^*_6 & x^*_7 & 0 & 0 & -x_3 & x_{17} \\
x^*_7 & -x_6 & -x_5 & x_4 & 0 & x_{18} \\
x^*_8 & 0 & 0 & -x^*_{11} & -x^*_{15} & -x^*_1 \\
0 & x^*_8 & 0 & x^*_{10} & x^*_{16} & -x^*_2 \\
0 & 0 & x^*_8 & x^*_9 & -x^*_{17} & -x^*_3 \\
0 & 0 & 0 & x^*_{18} & x^*_8 & -x^*_4 \\
0 & 0 & -x^*_{18} & 0 & x^*_9 & -x^*_5 \\
0 & -x^*_{18} & 0 & 0 & x^*_{10} & -x^*_6 \\
x^*_{18} & 0 & 0 & 0 & x^*_{11} & -x^*_7 \\
0 & -x^*_9 & x^*_{10} & 0 & x^*_{12} & x_1 \\
x^*_9 & 0 & x^*_{11} & 0 & x^*_{13} & x_2 \\
-x^*_{10} & -x^*_{11} & 0 & 0 & x^*_{14} & x_3 \\
-x^*_{12} & -x^*_{13} & -x^*_{14} & 0 & 0 & x_4 \\
-x^*_{16} & -x^*_{15} & 0 & -x^*_{14} & 0 & x_5 \\
-x^*_{17} & 0 & x^*_{15} & -x^*_{13} & 0 & x_6 \\
0 & -x^*_{17} & -x^*_{16} & x^*_{12} & 0 & x_7 \\
0 & x_{14} & -x_{13} & -x_{15} & x_{11} & 0 \\
x_{14} & 0 & -x_{12} & -x_{16} & x_{10} & 0 \\
-x_{13} & x_{12} & 0 & x_{17} & x_9 & 0 \\
x_{15} & -x_{16} & x_{17} & 0 & x_8 & 0 \\
-x_{11} & x_{10} & x_9 & -x_8 & x_{18} & 0
\end{pmatrix}$$

we have $G_6{}^H G_6 = D$, where D is a 6×6 diagonal matrix [9]. Clearly, the rate of $G_6$ is R = 18/30 = 0.6.

..

### III. Improved GCOD of Rates8/15for n = 6 Transmit Antennas

We present here complex orthogonal designs of grater than 1/2. The first one is a 15 × 8 matrix given by

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

$$D(1,1)=D(2,2)=D(3,3)=D(4,4)=D(5,5)=D(6,6)=D(7,7)=D(8,8)=\sum_{m=1}^{8}|x_m|^2$$

where rate R = 8/15 = 0.62 and the block length p (=15) in this example number of columns decreases and code rate improved

## IV CONCLUSION

Space–time block codes from (generalized) complex orthogonal designs have two advantages: fast ML decoding and full diversity. It has been proved in that the rate of these space–time block codes must be less than 1 except for the case of two transmit antennas. There is a systematic construction of complex orthogonal designs of rate 1/2 for any number of transmit antennas based on the Hurwitz–Radon theory. The previously known designs of rate larger than 1/2 and less than 1 were given only for three and four transmit antennas with rate 3/4. In this correspondence, we presented Improved and less time delay generalized complex orthogonal designs of rates 8/15 for six transmit antennas, respectively.

## V REFERENCES


[1] S. Alamouti, "A simple transmit diversity technique for wireless communications," *IEEE J. Select. Areas Commun.*, vol. 16, pp. 1451–1458, Aug. 1998..

[2] V. Tarokh, N. Seshadri, and A. R. Calderbank, "Space–time codes for high data rate wireless communication: Performance criterion and code construction," *IEEE Trans. Inform. Theory*, vol. 44, pp. 744–765, Mar. 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] , "Correction to 'Space–time block codes from orthogonal designs'," *IEEE Trans. Inform. Theory*, vol. 46, p. 314, Jan. 2000.

[5] G. Ganesan and P. Stoica, "Space–time block codes: A maximum SNR approach," *IEEE Trans. Inform. Theory*, vol. 47, pp. 1650–1656, May 2001.

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

[7] H. Wang and X.-G. Xia, "Upper bounds of rates of complex orthogonal space–time block codes," preprint, 2002.

[8] W. Su and X.-G. Xia, "On space–time block codes from complex orthogonal designs," Wireless Personal Commun., to be published.

[9] Weifeng Su; Xiang-Gen Xia "Two generalized complexorthogonal space-time block codes of rates 7/11 and 3/5 for 5 and 6transmit antennas" nformation theory,IEEE transactions volume49 page313-316