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Full Code Rate Complex Non-Orthogonal STBCS for Eleven Transmit Antennas

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Abstract— Alamouti is Pioneer of Complex Orthogonal STBCS for two transmit branch diversity with code rate one. Later Tarkoh investigated for four to nine transmit antennas with code rate 1/2. Jafarkhni proposed for non orthogonal STBCS four transmit antennas with code rate one. O. Tirkkonen and A. Hottinen Proposed space-time block codes for eight transmit antennas of code rate ½. Recently five, six, seven and eight transmit antennas generalized complex orthogonal space-time block codes of code rate with 2/3, 2/3,5/8, and 5/8 proposed. Bao.T. et. al. investigated OSTBC with maximal rates and minimal decoding for eight transmit antennas. The theory of OSTBC was further developed by Khaled A.M. et.al. who achieved full rate transmission for OSTBCs for six and eight antennas. This paper intends new matrix non-OSTBC for eleven transmit antenna with full code rate.

***Index Terms*—**Coderate, fading, MIMO, non-OSTBC, 2G, 3G, SISO, QOSTBC

I. Introduction

APage No.(roximately, more than 700 million people in the world are using the existing Second Generation and Third Generation (2G, 3G) wireless systems having the suPage No.(orting data rates of 9.6 Kbps to 2 Mbps. According to the recent IEEE 802.11, WLAN networks facilitate communication at rates of around 54 Mbps and have had more than 1.6 billion USD in equipment sales so far. In the next ten years, the capabilities of this technology are estimated to be from the 100 Mbps - 1Gbps and the subscribers number is expected to increase upto two billion. Now-a-days, the wireless communication research community and industry discuss standardization for the Fourth Generation (4G). The research society has generated a number of promising solutions for important improvements in system recital. One of the most capable future technologies in Wireless communications is multi antenna elements at the transmitter and at the receiver.

In radio, Multiple- Input and Multiple Output (MIMO), is the use of multiple antennas at both the transmitter and receiver to improve communication performance. MIMO is one of the antenna technologies, and the terms input and output refer to the radio channel. A wireless system generally consists of a transmitter, a radio channel and a receiver categorized by their number of inputs and outputs. The simplest configuration is a single antenna at both sides of the wireless link, denoted as Single-Input/Single Output (SISO) system. In a MIMO system multiple antennas can be used on one or both sides of the communication link.

MIMO technologies have gained significance because of

- Improved link reliability
- Enhanced spectral efficiency
- Achievement of array gain by distributing total transmitter power without additional bandwidth.
- Increased data throughput and link range.

Over the last few decades, due to an increased demand for wireless services, such as mobile phones, wireless internet, email, interactive multimedia communications, wireless communications have become one of the most important research fields. However, providing such services poses challenges like “how to increase transmission rates and capacity required for these aPage No.(lications without requiring additional bandwidth in a wireless channel”. Hence, new technologies have to be deployed since traditional methods are reaching their technical or financial limits.

II. Literature Review

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 was invented in 1998 for MIMO system, which has full transmitted diversity and can be decoded by maximum-likelihood method due to its orthogonality [2,3]. Yet, the code rate of an orthogonal STBC (OSTBC) is uPage No.(er bounded by 3/4 transmitted symbols per channel use for more than two transmit antennas [4]. As a result by relaxing orthogonality constraint, quasi-orthogonal STBC (QOSTBC) with code rate one and transmitted symbols per channel use is attained at the cost of higher decoding complexity [5].The space-time block codes exist with symbol transmission rates 7/11 and 3/5, respectively, from General Complex orthogonal designs with linear processing [7] for 5 and 6 transmit antennas. To show high rate OSTBCs of system design& Computer aided method for any number of transmit antennas is presented in [8].Similarly high rate OSTBCSfor 2k-1 or2k transmit antennas with code rates of$(k+1)/(2k)$ is found in [9]. X.B.Liang represented new OSTBC for eight transmit antennas by padding eight column to existing 7 transmit antennas. O. Tirkkonen and A. Hottinen [6] Proposed space-time block codes for eight transmit antennas of code rate ½.The present OSTBC for eight transmit antennas achieve same maximal rate 5/8 as well as same delay 56 of 7 transmit antennas [10].The theory of space-time block codes was further developed by M.A.Islam Jewel, M.Rahman[11]. They defined space time block codes in terms of orthogonal code matrices. The properties of these matrices ensure full rate for four transmit antennas. We proposed full rate for eight and sixteen transmit antennas [12][13] . O. Tirkkonen and A. Hottinen Proposed space-time block codes for eight transmit antennas with code rate ½. X.B.Liang [10] has reported OSTBC for ten transmit antennas, which transmit 252 information symbols in 420 time slots, a code rate of 3/5 resulted. Bao.T. et. al. [14] investigated OSTBC with maximal rates and minimal decoding for eight transmit antennas. Shen.Q et. al [15] proposed nonOSTBC schemes for four and three tr ansmit antennas with code rates of 2 and 1.5. The theor y of OSTBC was further developed by Khaled A.M. et.al. [16] who achieved full rate transmission for OSTBCs for six and eight antennas.

III. SPACE-TIME BLOCK CODES

STBCs are classified into two types: 1. OSTBCs and 2. QOSTBCs. An STBC for a number of transmit antennas 'n' is described by pxn code matrix G, where p is the number of time intervals for transmitting k symbols, resulting in a code rate of R = k/p. At the receiver, ML decoding algorithm is used to recover symbols.

Orthogonal Designs

There are two advantages in providing transmit diversity through orthogonal designs:

1. The orthogonal designs provide maximum transmission rate at full diversity, so that there is no loss of bandwidth
2. ML decoding algorithm, which uses linear combining at the receiver, is extremely simple due to Orthogonality of the columns of the orthogonal design.

The condition for orthogonal design is given in eq 1.1

$$G^H G = \left(|x_1|^2 + |x_2|^2 + \ldots\ldots + |x_k|^2\right) I_{nxn} \qquad 1.1$$

The condition for non-orthogonal design is given in eq 1.2

$$G^H G \neq \left(|x_1|^2 + |x_2|^2 + \ldots\ldots + |x_k|^2\right) I_{nxn} \qquad 1.2$$

IV. METHODOLOGY

The non-OSTBC ten matrices obtained full code rate in which number of symbols, number of time intervals is n(n-1) and number of Alamouti's matrices is n(n-1)/2. Here n represents number of transmit antennas.

V. RESULTS

The proposed non-OSTBC of code rate 1 for eleven transmit antennas where the block length with codeword p=112, carries information symbols k=112. Thus, one can get R =k/p=112/112=1.In matrix eq 1.3, the code rate is increased and decoding delay is decreased as compared to the existing matrix given by X.B.Liang [10].The design of complex orthogonal matrix eq 1.3,ten transmit antennas having code rate R =1 and the block length of p = 112. Hence, in comparison with the design of X.B.Liang [10], the code rate increases due to decrease in block length and the number of elements.

VI. CONCLUSIONS

For conventional complex codes of higher number of transmit antennas (ten to eighteen), the number of symbols and time delays is very large. The above problem is alleviated by using non-OSTBC concept reducing the number of symbols and time delays as shown in Table 1.1 which will reduce the complexity of the system.

TABLE 1.1 NON-OSTBCS FOR ELEVEN TRANSMIT ANTENNAS

	Number of Transmit Antennas	Symbols (k)	Delays (p)	Code rate (k/p)
Existing (Trakoh)	11	32	16	1/2
Existing (Liang)	11	462	792	7/12
Proposed	11	112	112	1
	Number of Transmit Antennas	Symbols (k)	Delays (p)	Code rate (k/p)

$$
G_{11}=\left[\begin{array}{ccccccccccc|ccccccccccc}
s_1 & s_2 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & s_{27} & 0 & s_{28} & 0 & 0 & 0 & 0 & 0\\
-s_2^* & s_1^* & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & -s_{28}^* & 0 & s_{27}^* & 0 & 0 & 0 & 0 & 0\\
0 & s_3 & s_4 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & s_{29} & 0 & s_{30} & 0 & 0 & 0 & 0\\
0 & -s_4^* & s_3^* & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & -s_{30}^* & 0 & s_{29}^* & 0 & 0 & 0 & 0\\
0 & 0 & s_5 & s_6 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & s_{31} & 0 & s_{32} & 0 & 0 & 0\\
0 & 0 & -s_6^* & s_5^* & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & -s_{32}^* & 0 & s_{31}^* & 0 & 0 & 0\\
0 & 0 & 0 & s_7 & s_8 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & s_{33} & 0 & s_{34} & 0 & 0\\
0 & 0 & 0 & -s_8^* & s_7^* & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & -s_{34}^* & 0 & s_{33}^* & 0 & 0\\
0 & 0 & 0 & 0 & s_9 & s_{10} & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & s_{35} & 0 & s_{36} & 0\\
0 & 0 & 0 & 0 & -s_{10}^* & s_9^* & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & -s_{36}^* & 0 & s_{35}^* & 0\\
0 & 0 & 0 & 0 & 0 & s_{11} & s_{12} & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & s_{37} & 0 & s_{38}\\
0 & 0 & 0 & 0 & 0 & -s_{12}^* & s_{11}^* & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & -s_{38}^* & 0 & s_{37}^*\\
0 & 0 & 0 & 0 & 0 & 0 & s_{13} & s_{14} & 0 & 0 & 0 & s_{39} & 0 & 0 & s_{40} & 0 & 0 & 0 & 0 & 0 & 0 & 0\\
0 & 0 & 0 & 0 & 0 & 0 & -s_{14}^* & s_{13}^* & 0 & 0 & 0 & -s_{40}^* & 0 & 0 & s_{39}^* & 0 & 0 & 0 & 0 & 0 & 0 & 0\\
0 & 0 & 0 & 0 & 0 & 0 & 0 & s_{15} & s_{16} & 0 & 0 & 0 & s_{41} & 0 & 0 & s_{42} & 0 & 0 & 0 & 0 & 0 & 0\\
0 & 0 & 0 & 0 & 0 & 0 & 0 & -s_{16}^* & s_{15}^* & 0 & 0 & 0 & -s_{42}^* & 0 & 0 & s_{41}^* & 0 & 0 & 0 & 0 & 0 & 0\\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & s_{17} & s_{18} & 0 & 0 & 0 & s_{43} & 0 & 0 & s_{44} & 0 & 0 & 0 & 0 & 0\\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & -s_{18}^* & s_{17}^* & 0 & 0 & 0 & -s_{44}^* & 0 & 0 & s_{43}^* & 0 & 0 & 0 & 0 & 0\\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & s_{19} & s_{20} & 0 & 0 & 0 & s_{45} & 0 & 0 & s_{46} & 0 & 0 & 0 & 0\\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & -s_{20}^* & s_{19}^* & 0 & 0 & 0 & -s_{46}^* & 0 & 0 & s_{45}^* & 0 & 0 & 0 & 0\\
s_{21} & 0 & s_{22} & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & s_{47} & 0 & 0 & s_{48} & 0 & 0 & 0\\
-s_{22}^* & 0 & s_{21}^* & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & -s_{48}^* & 0 & 0 & s_{47}^* & 0 & 0 & 0\\
0 & s_{23} & 0 & s_{24} & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & s_{49} & 0 & 0 & s_{59} & 0 & 0\\
0 & -s_{24}^* & 0 & s_{23}^* & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & -s_{50}^* & 0 & 0 & s_{49}^* & 0 & 0\\
0 & 0 & s_{25} & 0 & s_{26} & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & s_{51} & 0 & 0 & s_{52} & 0\\
0 & 0 & -s_{26}^* & 0 & s_{25}^* & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & -s_{52}^* & 0 & 0 & s_{51}^* & 0
\end{array}\right]
$$

$$
\begin{vmatrix}
0 & 0 & 0 & 0 & 0 & 0 & 0 & s_{53} & 0 & 0 & s_{54} \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & -s_{54}^{*} & 0 & 0 & s_{53}^{*} \\
s_{55} & 0 & 0 & 0 & s_{56} & 0 & 0 & 0 & 0 & 0 & 0 \\
-s_{56}^{*} & 0 & 0 & 0 & s_{55}^{*} & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & s_{57} & 0 & 0 & 0 & s_{58} & 0 & 0 & 0 & 0 & 0 \\
0 & -s_{58}^{*} & 0 & 0 & 0 & s_{57}^{*} & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & s_{59} & 0 & 0 & 0 & s_{60} & 0 & 0 & 0 & 0 \\
0 & 0 & -s_{60}^{*} & 0 & 0 & 0 & s_{59}^{*} & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & s_{61} & 0 & 0 & 0 & s_{62} & 0 & 0 & 0 \\
0 & 0 & 0 & -s_{62}^{*} & 0 & 0 & 0 & s_{61}^{*} & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & s_{63} & 0 & 0 & 0 & s_{64} & 0 & 0 \\
0 & 0 & 0 & 0 & -s_{64}^{*} & 0 & 0 & 0 & s_{63}^{*} & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & s_{65} & 0 & 0 & 0 & s_{66} & 0 \\
0 & 0 & 0 & 0 & 0 & -s_{66}^{*} & 0 & 0 & 0 & s_{65}^{*} & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & s_{67} & 0 & 0 & 0 & s_{68} \\
0 & 0 & 0 & 0 & 0 & 0 & -s_{68}^{*} & 0 & 0 & 0 & s_{67}^{*} \\
s_{69} & 0 & 0 & 0 & 0 & s_{70} & 0 & 0 & 0 & 0 & 0 \\
-s_{70}^{*} & 0 & 0 & 0 & 0 & s_{69}^{*} & 0 & 0 & 0 & 0 & 0 \\
0 & s_{71} & 0 & 0 & 0 & 0 & s_{72} & 0 & 0 & 0 & 0 \\
0 & -s_{72}^{*} & 0 & 0 & 0 & 0 & s_{71}^{*} & 0 & 0 & 0 & 0 \\
0 & 0 & s_{73} & 0 & 0 & 0 & 0 & s_{74} & 0 & 0 & 0 \\
0 & 0 & -s_{74}^{*} & 0 & 0 & 0 & 0 & s_{73}^{*} & 0 & 0 & 0 \\
0 & 0 & 0 & s_{75} & 0 & 0 & 0 & 0 & s_{76} & 0 & 0 \\
0 & 0 & 0 & -s_{76}^{*} & 0 & 0 & 0 & 0 & s_{75}^{*} & 0 & 0 \\
0 & 0 & 0 & 0 & s_{77} & 0 & 0 & 0 & 0 & s_{78} & 0 \\
0 & 0 & 0 & 0 & -s_{78}^{*} & 0 & 0 & 0 & 0 & s_{77}^{*} & 0
\end{vmatrix}
$$

$$
\begin{vmatrix}
0 & 0 & 0 & 0 & 0 & s_{79} & 0 & 0 & 0 & 0 & s_{80} \\
0 & 0 & 0 & 0 & 0 & -s_{80}^{*} & 0 & 0 & 0 & 0 & s_{79}^{*} \\
s_{81} & 0 & 0 & 0 & 0 & 0 & s_{82} & 0 & 0 & 0 & 0 \\
-s_{82}^{*} & 0 & 0 & 0 & 0 & 0 & s_{81}^{*} & 0 & 0 & 0 & 0 \\
0 & s_{83} & 0 & 0 & 0 & 0 & 0 & s_{84} & 0 & 0 & 0 \\
0 & -s_{84}^{*} & 0 & 0 & 0 & 0 & 0 & s_{83}^{*} & 0 & 0 & 0 \\
0 & 0 & s_{85} & 0 & 0 & 0 & 0 & 0 & s_{86} & 0 & 0 \\
0 & 0 & -s_{86}^{*} & 0 & 0 & 0 & 0 & 0 & s_{85}^{*} & 0 & 0 \\
0 & 0 & 0 & s_{87} & 0 & 0 & 0 & 0 & 0 & s_{88} & 0 \\
0 & 0 & 0 & -s_{88}^{*} & 0 & 0 & 0 & 0 & 0 & s_{87}^{*} & 0 \\
0 & 0 & 0 & 0 & s_{89} & 0 & 0 & 0 & 0 & 0 & s_{90} \\
0 & 0 & 0 & 0 & -s_{90}^{*} & 0 & 0 & 0 & 0 & 0 & s_{89}^{*} \\
s_{91} & 0 & 0 & 0 & 0 & 0 & 0 & s_{92} & 0 & 0 & 0 \\
-s_{92}^{*} & 0 & 0 & 0 & 0 & 0 & 0 & s_{91}^{*} & 0 & 0 & 0 \\
0 & s_{93} & 0 & 0 & 0 & 0 & 0 & 0 & s_{94} & 0 & 0 \\
0 & -s_{94}^{*} & 0 & 0 & 0 & 0 & 0 & 0 & s_{93}^{*} & 0 & 0 \\
0 & 0 & s_{95} & 0 & 0 & 0 & 0 & 0 & 0 & s_{96} & 0 \\
0 & 0 & -s_{96}^{*} & 0 & 0 & 0 & 0 & 0 & 0 & s_{95}^{*} & 0 \\
0 & 0 & 0 & s_{97} & 0 & 0 & 0 & 0 & 0 & 0 & s_{98} \\
0 & 0 & 0 & -s_{98}^{*} & 0 & 0 & 0 & 0 & 0 & 0 & s_{97}^{*} \\
s_{99} & 0 & 0 & 0 & 0 & 0 & 0 & 0 & s_{100} & 0 & 0 \\
-s_{100}^{*} & 0 & 0 & 0 & 0 & 0 & 0 & 0 & s_{99}^{*} & 0 & 0 \\
0 & s_{101} & 0 & 0 & 0 & 0 & 0 & 0 & 0 & s_{102} & 0 \\
0 & -s_{102}^{*} & 0 & 0 & 0 & 0 & 0 & 0 & 0 & s_{101}^{*} & 0 \\
0 & 0 & s_{103} & 0 & 0 & 0 & 0 & 0 & 0 & 0 & s_{104} \\
0 & 0 & -s_{104}^{*} & 0 & 0 & 0 & 0 & 0 & 0 & 0 & s_{103}^{*}
\end{vmatrix}
$$

$$\begin{bmatrix} s_{105} & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & s_{106} & 0 \\ -s_{106}^{*} & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & s_{105}^{*} & 0 \\ 0 & s_{107} & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & s_{108} \\ 0 & -s_{108}^{*} & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & s_{107}^{*} \\ s_{109} & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & s_{110} \\ -s_{110}^{*} & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & s_{109}^{*} \end{bmatrix} \quad 1.3$$

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