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A Comparative Study of Coordinate Interleaved Orthogonal Design

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ABSTRACT: Space time block code is a transmit diversity strategy used in MIMO technology. STBC-OD design is an attractive code which is having the property of full code rate and full diversity and single symbol decoding for two transmit antennas. Whereas this codes fails for the rate-1 transmission of more than two transmit antennas with the complex signal constellations. To achieve a full code rate and full diversity Space-time block code from coordinate interleaved orthogonal design (STBC-CIOD) is used in this paper.

KEYWORDS: Space-time coding, multiple-antenna systems, STBC-CIOD design.

I.INTRODUCTION

Over a past decades wireless communication is an important one which supports a wide range of applications like voice and video, email, web browsing. These are the some of the application and essential part of our daily life. But there is a demand for providing such a reliable communication due to effects of some wireless impairment like shadowing and multipath effects. Due to this effect in radio communication information carrying electromagnetic signal met with surrounding environments such as obstacles, buildings, hills. Thus the wave fronts are scattered and they take many paths to reach the destination is called multipath effects. The later arrival of scattered portions of the signal causes the problems such as fading and it will also increases some errors. Also this wireless communication is shared by many users and applications which create the problems called interference. These are major problem of wireless communication. Because of these problem we cannot able to utilize the available bandwidth efficiently and the transmit power, hardware complexity, cost also gets increased. MIMO technology takes advantages of multipath effect. The technology offers a number of benefits that help meet the challenges posed by both the impairments in the wireless channel as well as resource constraints. In addition to the diversity technique are exploited in MIMO are realized by exploiting the spatial diversity (provided by the multiple antennas at the transmitter and the receiver). The widely used diversity technique is time, frequency diversity. This sort of diversity technique is used to improve the performance of wireless communication over a fading channel. Spatial diversity is an effective approach to increase the rate of wireless communication without increasing the additional bandwidth and power. This paper is organized as follows. Space time block codes is presented in section II, system model and Design of STBC-CIOD code designs are provided in section III, performance analysis in section IV, Conclusions in section V.

II SPACE TIME BLOCK CODES

Space time block coding is a transmit strategy in MIMO technology this technology takes the advantage of time and frequency diversity. Space time block codes are usually represented by a channel matrix.

Let us Assume N be the no of transmit antennas and M be the no of receiving antennas, T is a time slot and for a each time slot T signal points S_{it} (i=0,1,2……N-1) are transmitted from the N transmit antennas simultaneously, $h_{ij}=\alpha_{ij}e^{j\theta ij}$ is the path gain from i^{th} transmit antenna to the j^{th} receive antenna. And also assume that this path gains are constant over L≥N, t=0,….L-1, ϑ_{ij} is the received signal at a jth antenna over a T time slots .

Received signal is denoted by.

$\vartheta_{ij=} = \sum_{i=0}^{n-1} hij\ Sit + njt$ where j=0,….M-1; t=0,…….L-1

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In matrix representation

$$= \begin{bmatrix} s_{00} & s_{01} & .. & s_{0L-1} \\ s_{10} & s_{11} & .. & s_{1L-1} \\ : & : & : & : \\ s_{M-10} & s_{N-12} & .. & s_{N-1L-1} \end{bmatrix} \begin{bmatrix} h_{00} & h_{01} & .. & h_{0M-1} \\ h_{10} & h_{11} & .. & h_{1M-1} \\ : & : & : & : \\ h_{N-10} & h_{N-11} & .. & h_{N-1M-1} \end{bmatrix} + \begin{bmatrix} n_{00} & n_{11} & .. & n_{M-11} \\ n_{01} & n_{12} & .. & n_{M-12} \\ : & : & : & : \\ n_{0L-1} & n_{1L-1} & .. & n_{L-1M-1} \end{bmatrix}$$

Received signal vector can be calculated as

V=SH+N

Space time block codes from orthogonal design (COD) which is also known as Alamouti code is a attracting one due to their full code rate and single symbol ML decoding for a complex constellations. The drawback of this code is for more than two transmit antennas it sacrifice these advantages that is for more no of antennas this Alamouti code provides the full diversity with a less code rate. Space time block codes from QOD provides the full code rate, full diversity for more no of antennas but this code attracts a double decoding complexity. Whereas the another code has been significant interest in providing a full code for more than two transmit antennas, which is called space time block code from coordinate interleaved orthogonal (STBC-CIOD) codes, since this code posses a advantage of providing full diversity and full code rate(rate-1) with a single symbol decoding for any complex constellations.

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III SYSTEM MODEL

From fig 1: The information symbols are encoded using STBC-CIOD codes after the encoding the symbols are given to the mapping section and the mapped symbols are transmitted parallel using no of antennas. We assume that no of transmit and receive antenna at source and the destination is four. Channel coefficients among the source and destination is assumed to be Rayleigh fading with mutually independent and additive white Gaussian noise(AWGN) having zero mean and variance $N(0,\sigma^2)$ and also assume that the perfect channel state information is available only at the receiver to decode the original transmit signal.

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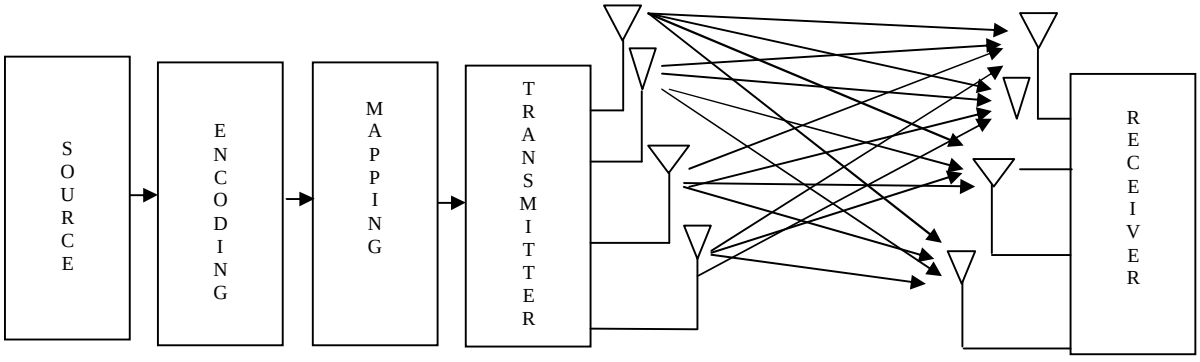

Fig 1**:** system model of transmission using 4 transmit antenna and 4 receive antenna with a STBC-CIOD technique

COORDINATE INTERLEAVED ORTHOGONAL DESIGN

This code provides a full diversity full code rate for more no of antennas. In this scheme we are interleaving the inphase and quadrature components of the variables of a design in order to face the different levels of fading and wireless impairments.

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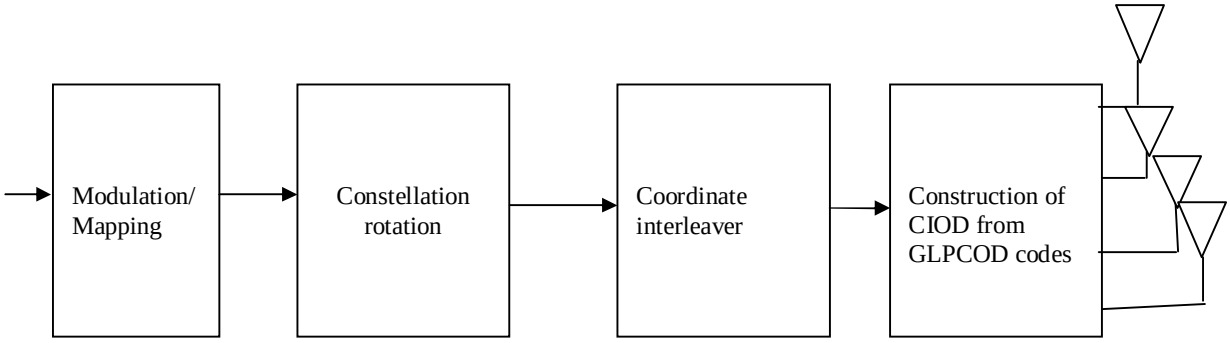

Fig 2: Block diagram of CIOD codes

From the fig 2: information symbols are given to the mapping (16QAM) section and the mapped symbols are rotated by angle θ (θ=31.7175°)

COORDINATE INTERLEAVED DESIGN FOR FOUR ANTENNAS

Let x_i be the complex indeterminate, where $x_i=x_iI+jx_iQ$, (i=0,1,2,3,4), x_iI and jx_iQ are the real and imaginary part of x_i. The coordinate interleaved design of x_i will be $Xi^{\sim}=x_iI+jx_{(i+K/2)K}$ Q, coordinate interleaved version for four complex in determinates are

$x_0^{\sim}=x_{0,}I+jx_{2,}Q$
$x_1^{\sim}=x_{1,}I+jx_{3,}Q$
$x_2^{\sim}=x_{2,}I+jx_{0,}Q$
$x_3^{\sim}=x_{3,}I+jx_{1,}Q$

The transmitted symbols using STBC-CIOD at the source is given by

$$S(x_0.....x_3)=\begin{bmatrix} \tilde{x}_0 & \tilde{x}_1 & 0 & 0 \\ -\tilde{x}_1 & \tilde{x}_0 & 0 & 0 \\ 0 & 0 & \tilde{x}_2 & \tilde{x}_3 \\ 0 & 0 & -\tilde{x}_3^{*} & \tilde{x}_2^{*} \end{bmatrix}$$

$$=\begin{bmatrix} x_0,I+jx_2,Q & x_1I+jx_3,Q & 0 & 0 \\ -x_1,I+jx_3,Q & x_0I-jx_2,Q & 0 & 0 \\ 0 & 0 & x_2,I+jx_0,Q & x_3,I+Jx_1,Q \\ 0 & 0 & -x_3,I+jx_1Q & x_2,I-jx_0,Q \end{bmatrix}$$

To achieve a full diversity and full code rate the symbols are rotated by θ=31.7175° [1], from the above matrix in first time interval the first two antenna will transmit a information and another two antenna will transmit nothing, in second time period first two antenna will transmit nothing and another two antenna will transmit a information.

The received signal will be

$$\begin{bmatrix} v_{j0} \\ v_{j1}^{*} \\ v_{j2} \\ v_{j3}^{*} \end{bmatrix} = \begin{bmatrix} h_{0j} & h_{1j} & 0 & 0 \\ h_{1j}^{*} & -h_{0j}^{*} & 0 & 0 \\ 0 & 0 & h_{2j} & h_{3j} \\ 0 & 0 & h_{3j}^{*} & -h_{2j}^{*} \end{bmatrix} \begin{bmatrix} \tilde{s}_0 \\ \tilde{s}_1 \\ \tilde{s}_2 \\ \tilde{s}_3 \end{bmatrix} + \begin{bmatrix} n_{j0} \\ n_{j1}^{*} \\ n_{j2} \\ n_{j3}^{*} \end{bmatrix}$$

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V_{jt} is a received signal at a time slot t where t=0,1,2,3,4 and $h_{ij}$is a path gain, S_i is a transmitted symbols and this S_i is replaced by x_i, n is a AWGN noise. Comparison of CIOD, COD and QOD codes is shown in table 1: from this table CIOD is the only code which provides the advantage of full code rate and full diversity with a single symbol decoding for more than two transmit antennas. Also table 2: code rate of ciod codes, which provides the better code rate than another codes.

Table 1: Comparison of OSTB, QSTBC and CIOD

Codes	Symbol rate	Diversity	Decoding
STBC-OD's	3/4	4	SSD
QOD[1,2]	1	4	DSD
QOD[3,4]	1	4	DSD
QOD[5,6]	1	4	DSD
CIOD	1	4	SSD

Table 2: Code rate of CIOD

CODES	M=2	M=3,4	M=5,6	M=7,8
OSTBC	1	¾	2/3	5/8
MDC-QSTBC	1	1	3/4	¾
CIOD	1	1	6/7	4/5

SOURCE: D˜ung Ngo & Đào,C & Chintha Tellambura, 2008, 'Decoding, Performance Analysis, and Optimal Signal Designs for Coordinate Interleaved orthogonal designs, IEEE, vol.7,no.1,januray.

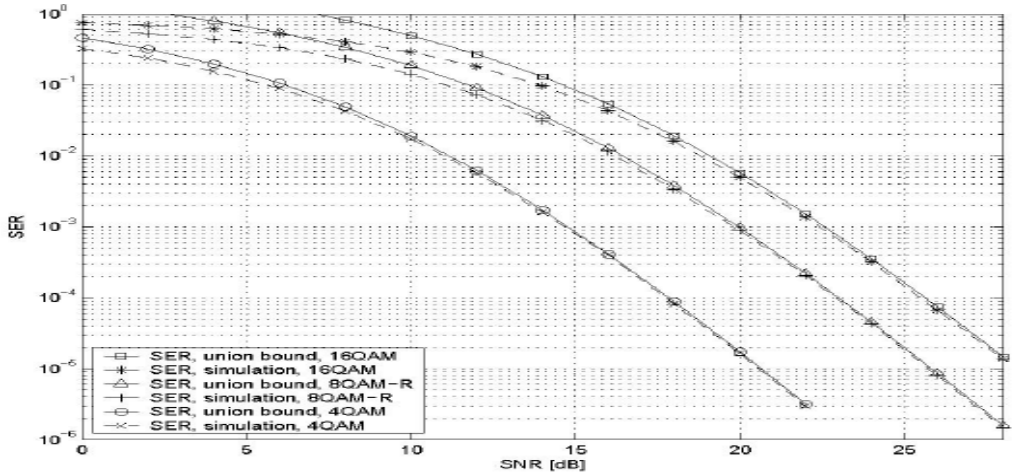

Fig 3: comparison of simulated result of SER and union bound of a rate-one CIOD for 4 Tx antennas using 1Rx antenna.

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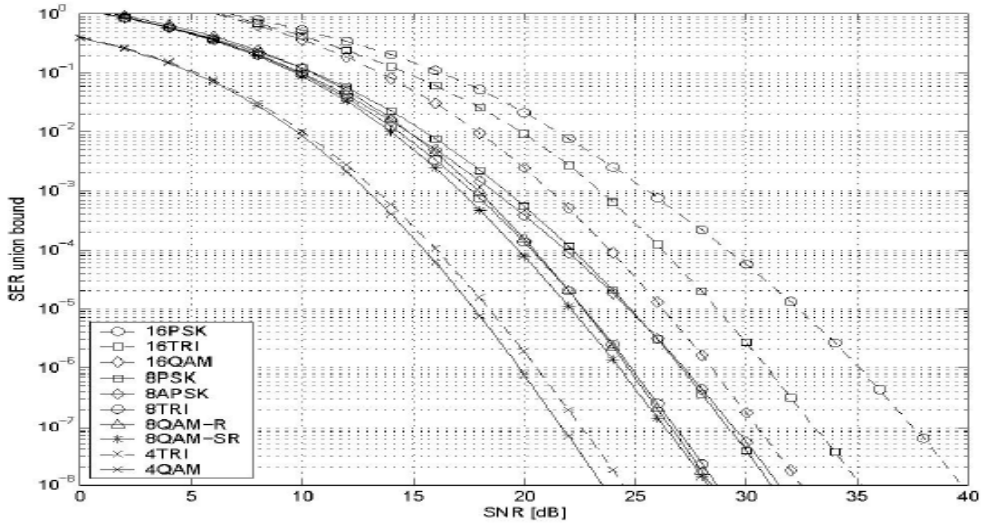

Fig 4: SER union bound a CIOD code with rate of 6/7 for 6 Tx antannas using 1Rx antenna.

SOURCE: D˜ung Ngo & Đào,C & Chintha Tellambura, 2009, 'On Space-Time Block Codes from Coordinate Interleaved Orthogonal Designs, *IEEE*,vol.7,no.1,December 21.

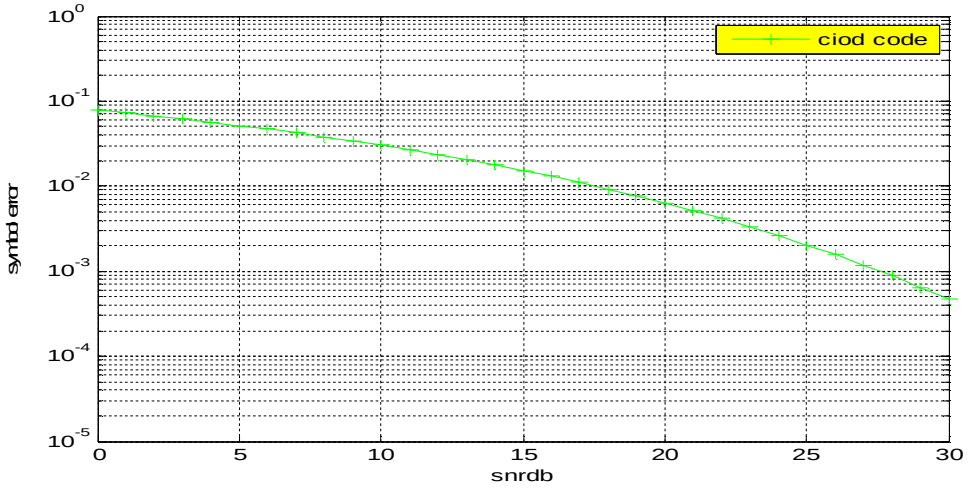

Fig 5: performance of CIOD codes for 4x4 antennas

V CONCLUSION

In this paper 4x4 antenna with the STBC-CIOD code is analyzed. The fig 3 shows the performance analysis of 4 transmit antenna using 1 receive antenna with CIOD design, for a 16QAM this code design achieves the above 25db snr for 0.1 symbol error. Fig 4 shows the performance of CIOD codes for 6 Tx antennas using 1 Rx antenna achieves the 35 db snr for a 0.1 symbol error. From fig 5 for 4x4 antennas using CIOD code design we may achieve the 30 db snr for a 0.1 symbol error. Thus by using the CIOD codes we may achieve better code rate and full diversity .

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