MIMO Organization Applying Space-Time Block Computer Code with Cyclic Codes

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Abstract

Multiple-input and Multiple-output, (MIMO), is the use of multiple antennas at both the sender and receiver to improve the communicating functioning. MIMO engineering has pulled care in wireless communications, because it extends important increase in data throughput and link range without additional bandwidth or transmit power. In this research work, MIMO systems with reduced complexity are considered. The space– time block coding, for communication over Rayleigh fading channels using multiple transmit antennas is considered. The scheme is designed by using the cyclic code with rate 1/2 and 1/3, leading to a flexible and exploit of STBC for multiple antenna systems. Our proposed scheme minimizes the average Bit Error Ratio (BER) and betters the system diversity even if only a Maximum Likelihood (ML) receiver is used. The emulation models have been developed using simulation software and send them through a Raleigh channel to analyze the performance in terms of BER vs. Signal to Noise Ratio (SNR). It has been shown that the Altamonte scheme using cyclic code is extremely robust against MIMO Raleigh melting channel and thus outperforms other transmission schemes.

Keywords

Multiple Input/Multiple Output (MIMO), Space-Time Block Codes (STBC), Cyclic Codes

I. Introduction

Wireless systems are facing numerous challenges, including limited radio-frequency spectrum and signal transmission scheme due to fading and multipath distortions. Meantime, there is also rapidly increasing demand for high data rate, better Quality Of Service (QoS) and higher capacity. Multiple-input multiple-output technology promises a cost-effective way to provide these capabilities. However, Space-Time Coding (STC) is an effective channel coding of symbols across space and time can be done to obtain the advantages due to coding and diversity. Space-Time Block Codes (STBCs) from orthogonal design recently proposed by Alamouti and new breakthrough for research due to the Maximum-Likelihood (ML) decoding and full diversity. For space-time block codes, from both real and (Generalized) Complex Orthogonal Designs (GCODs) with or without linear processing, Tarokh, Jafarkhani and Calderbank showed that their rates cannot be greater than one [1-4]. Furthermore, the decade old design of orthogonal theory has recently invoked considerable interests to design STBC transmission matrix in multiple antenna systems [5]. Most of orthogonal STBC scheme depend on Radon-Hurwitz theory and unique design in terms of complex signal constellations for two transmit antennas and MR receive antennas. There are some treatments of orthogonal design can be found [6]. They have been shown that the set of real orthogonal design exists in square and non-square matrix with real and complex entries. The purpose of this research work is to evaluate the performance of the OSTBCs utilizing Cyclic codes with rate 1/2and 1/3 to achieve high diversity gain for two transmit antennas and MR receive antennas. The remainder of this work is organized as follows. In Section II, MIMO Principle is illustrated. In Section III, Code Design is described. In Section IV, we discuss the fundamentals of cyclic codes. In Section V. we introduce the concept of diversity Simulation Result and Conclusion can be found in Section VI, and VII, respectively.

II. MIMO Systems Principles

In this research work the multi-antenna system is considered. A digital source in the form of a binary data stream is fed to a simplified transmitting block encompassing the functions of error control coding and mapping to complex modulation symbols such as Binary Phase shift Keying (BPS K), Quadrature Phase shift keying(QPSK),. The latter produces several separate symbol streams which range from independent to partially redundant to fully redundant. Each is then mapped onto one of the multiple transmitting antennas. Mapping may include linear spatial weighting of the antenna elements or linear antenna space–time coding. After upward frequency conversion, filtering and amplification, the signals are launched into the wireless channel. At the receiver, the signals are captured by possibly multiple antennas and demodulation and de mapping operations are performed to recover the message. This determines the class and performance of the multi-antenna solution that is implemented If one estimates the response of each antenna element to a given desired signal, and possibly to interference signal(s), one can optimally combine the elements with weights selected as a function of each element response. One can then maximize the average desired signal level or minimize the level of other components whether noise or co-channel interference. When combined together, leverages of antennas are shown to improve the coverage range versus quality tradeoff offered to the wireless user. This makes multiple antenna elements transceivers a possibility at both sides of the link, even though pushing much of the processing and cost to the network's side still makes engineering sense. In fact, the advantages of MIMO are far more fundamental. While coding and signal processing are key elements to successful implementation of a MIMO system, the propagation channel and antenna design represent major parameters that ultimately impact system performance.

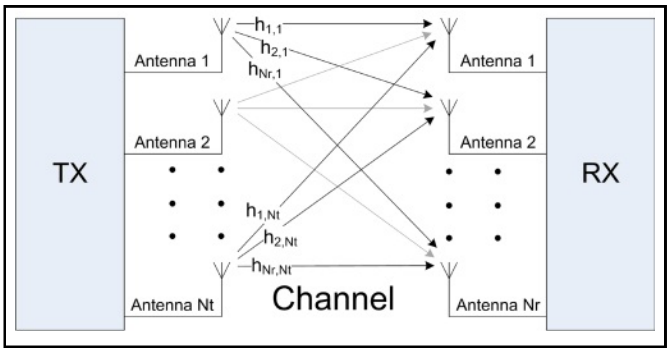

Fig. 1: MIMO System

III. Code Design

This scheme transmits the same information from both antennas simultaneously but with a delay of one symbol interval. We can view this as a special case of the arrangement in Fig. 2, where the information is encoded by a channel code. In order to provide improved performance while maintaining the same transmission rate it has been proposed a new method of codes for this application referred to as the Space– Time Codes. The restriction imposed by the delay element in the transmitter is first removed. Then performance criteria are established for code design assuming that the fading from each transmit antenna to each receive antenna is Rayleigh. Space–time trellis coding is a recent proposal that combines signal processing at the receiver with coding techniques appropriate to multiple transmits antennas. Specific space–time trellis codes designed for two transmitting and receiving antennas perform extremely well in slow-fading environments, typically of indoor transmission. However, when the number of transmit antennas is fixed, the decoding complexity of space–time trellis codes increases exponentially with transmission rate. When the receiver has multiple antennas, the transmit beam forming cannot simultaneously maximize the signal level at all of the receive antennas, and pre coding with multiple streams is used.

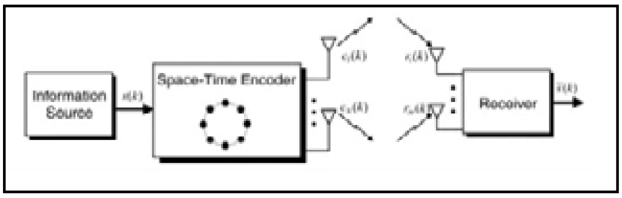

Fig. 2: STBC –Encoder

IV. Fundamental of Cyclic Codes

Cyclic codes are a subset of linear block codes [6-7]. It is used for error detection is referred to as a Cyclic Redundancy Check (CRC) code. However, a cyclic code has a rich algebraic structure that leads to strong error correcting capabilities and to computationally efficient encoding and decoding algorithms The linear code word C (which is made up n elements) is a cyclic code if it is invariant under a cyclic shift and expressed as

c=(c0,c1,c2,K ,cn_2,cn_1)_C (1)

if and only if

c%=(cn_,c,c1,K,cn_3,cn_2)_C (2)

The linear code word C is invariant under this single right cyclic shift, by iteration it is invariant under any number of right cyclic shifts. As a single left cyclic shift is the sambas n _1 right cyclic shifts, is also invariant under a single left cyclic shift and hence all left cyclic shifts. Therefore the linear code word C is cyclic precisely when it is invariant under all cyclic shifts. Given the cyclic generator matrix G , cyclic encoding is the process of encoding the message k _ topple 0 1 (, ,) k m m m_ = K into the codeword=m G. At the polynomial level, this corresponds to encoding the message polynomial. The code polynomial is

c(x) =m(x)g(x)

Since the cyclic generator G is in echelon form, the first k coordinate positions form an information set.

$$m(x) = \sum_{i=0}^{k-1} m_i x^i$$

nsider the case of complex entries for any Orthogonal Design (OD), (S_1,S_2,S_3,S_K) with variable x_1,x_2,x_3,x_K as a matrix S of order n with complex entries satisfying

MIMO System using Space -Time Block Code with Cyclic Codes

$$S^H S = \left(\sum_{i=1}^{k} s_i \, x_i^2 \right) \mathrm{I_n}$$

e matrix S is a complex matrix and its Hermitian transpose is SH. It can be simplified to the following:

$$S^H S = \left(\sum_{i=1}^{k} s_i \, x_i^2 \right) \mathrm{I_n} = \sum_{i=1}^{k} s^2 i \, \mathrm{I_n}$$

V. Diversity

Diversity is an effective method to reduce the multi path fading and signal attenuation of the wireless channel [8-9]. In time varying channel, signal always fluctuate and create deep fade, if the signal fluctuate very fast then it is defined as fast fading and increased high BER result. There are two types of space diversity namely transmit diversity and receiver diversity.

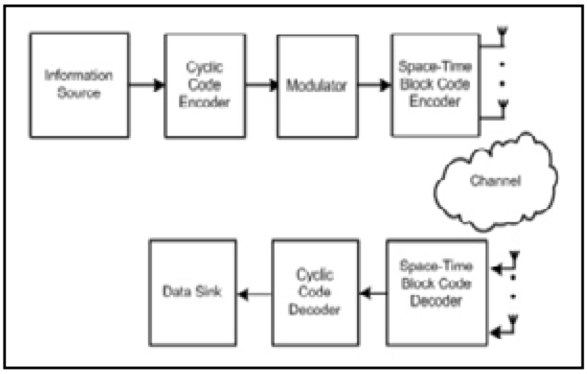

Fig. 3:

VI. System Model

Consider a system with (MT) Transmit antennas and (MR) receive antennas. A STBC is defined as MT X Q transmission matrix S. Here Q represents the number of time periods for transmission of one block of coded symbols. In our systems, the information bits are first encoded using cyclic code encoder then it is encoded using modulation scheme. The modulated symbols are feed for STBC encoder.

It is condition that the transmission matrix is must satisfy the terms of Complex Orthogonal Design (COD). The modulated signals are encoded by a space-time block encoder to generate MT parallel signal sequences of length Q according to the transmission matrix S. These sequences are transmitted through MT transmit antennas simultaneously in Q time periods. Let us consider Alamouti scheme based on with cyclic codes with rate 1/2 and 1/3for two transmit antennas and one (more) receive antenna respectively. The first row represents the first transmission period and simultaneously the second row represents the second transmission period. In first transmission period, two signals x_1 and x_2 are transmitted simultaneously from antenna one and antenna two. In the second transmission period, signal $*\_x_2$ and $*x_1$ are transmitted from antenna one two respectively, where $*x_1$ is the complex conjugate of x_1. The transmission coding scheme must satisfied the general expression which is ensure orthogonally.

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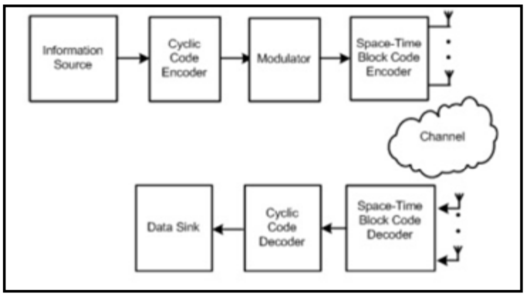

Fig. 4: System Model

A. Cyclic Codes Decoding Approach

The independent signal x_1 and x_2 are used for linear cyclic code decoder. In cyclic code, determine first codeword received is in C or not then (if not) we must determine the closest codeword in C. In order to determine if the code we received is in fact a codeword from C, we implement the help of a check polynomial. A check polynomial is a polynomial l(x) such that l(x)*g(x) = C. It is used to find the criteria for determining the validity of codeword are given by [9-10].The matrix L is the generator matrix for a code that is orthogonal to the cyclic codeword. It is comprised of right cyclic shifts of the string l=lk,lk_1K l0, where l is orthogonal to any codeword c=(c0,c1,c2,K,cn_2,cn_1)_C.

VII. Results and Discussion

The BER measurement for the simulation model is done using Monte Carlo simulation. In this method, the differences between input and output bits are calculated to measurable values. We evaluate the performance of the orthogonal STBC using cyclic codes for multiple antenna systems. Orthogonal STBC is measured based on Alamouti's code and used for two transmit antennas and one (or more) receive antenna model. In our simulations, we have used a coherent BPSK constellation. The element of the channel matrix H is considered Rayleigh distribution [7-8]. At the receiver side, we have used ML receivers for orthogonal STBC. On the other hand, a simple linear block code decoder is used for Cyclic code. The BER results have been averaged over 80,000information bits.

Table 1: Comparison of SNR and BER for 2X1 Antenna

Sl.No	Code rate	1/2	Code rate 1/3	
	SNR (dB)	BER	SNR (dB)	BER
1	15	$2X10^{-4}$	10	$3X10^{-4}$
2	14	$3X10^{-4}$	9	$4X10^{-4}$
3	12	$1X10^{-3}$	7	$8X10^{-4}$
4	10	$6X10^{-3}$	6	$4X10^{-3}$
5	6	$2X10^{-2}$	5	$5X10^{-3}$
6	5	$4X10^{-2}$	4	$8X10^{-3}$

Table 2: Comparison of SNR and BER for 2X2 Antenna

Sl.No	Code rate	1/2	Code rate 1/3	
	SNR (dB)	BER	SNR (dB)	BER
1	11	$2X10^{-5}$	6	$1X10^{-5}$
2	9	$1X10^{-4}$	5	$8X10^{-5}$
3	8	$2X10^{-4}$	4	$2X10^{-4}$
4	7	$8X10^{-4}$	3	$8X10^{-4}$
5	6	$1X10^{-2}$	2	$9X10^{-4}$
6	5	$4X10^{-3}$	1	$1X10^{-3}$

VIII. Conclusion

We developed an Orthogonal Space-Time Block Codes (OSTBCs) which is combination of cyclic code that achieves full rate and full diversity for two transmit antennas and MR receive antennas with coherent BPSK modulation. Its encoding and decoding complexity is simple and always performs better. A basic guideline is described to the design of STBC in terms of complex signal constellations. Since orthogonal design can be traced back to decades and have recently breakthrough for research in multiple antenna systems. One of the intentions of this research work is to provide an overview of orthogonal design of STBCs concatenated cyclic codes for MIMO systems.

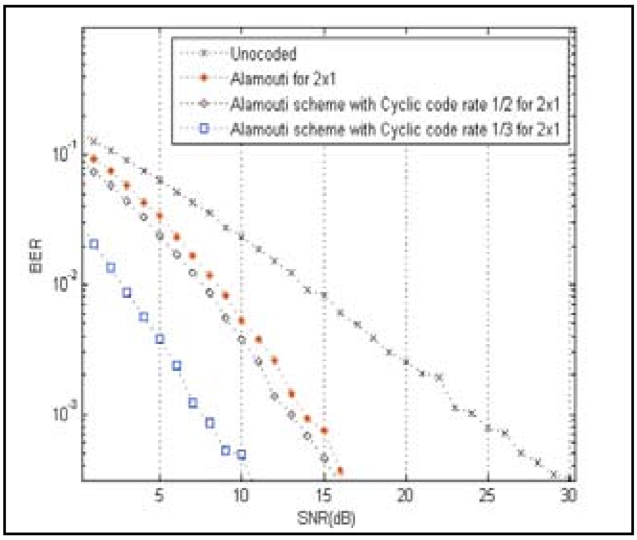

Fig. 5: SNR vs. BER Performance Alamouti's Code and Cyclic codes rate 1/2,1/3 with Alamouti Scheme for Two Transmit Antennas and Single Receive Antenna Systems

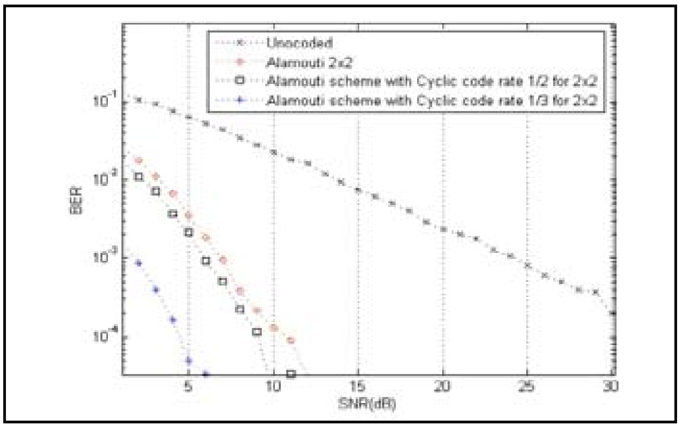

Fig. 6: SNR vs. BER Performance Alamouti's Code and Cyclic Codes Rate 1/2, 1/3 With Alamouti Scheme for Two Transmit and Receive Antennas System

IX. Scope of Future Work

In this research, work the orthogonal design of STBC with cyclic codes for code rate 1/2,1/3 of two transmit antennas and single receive antenna systems were described. The SNR&BER performance can be improved if STBC is replaced with space time complementary block coding and implemented with OFDM can give better result.

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