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A Novel Permutation Spreading for MIMO-CDMA Based on STBC

P.Dhanababu [1]& P. A. Nageswar Rao[2]
1, 2 Department of Electronics and Communication Engineering Dadi Institute of Engineering and Technology, Anakapalli, Visakhapatnam (A.P.)

ABSTRACT:-

CDMA is one of the channelization protocols that support more number of users simultaneously and asynchronously. It uses spreading technique that spreads information bearing signals, so that only intended receiver can able to receive it thus provides security. Here proposed a novel method is for designing the spreading permutations based on STBC (space time block code) matrices for MIMO-CDMA systems. The performance of the two techniques for MIMO-CDMA systems operating on frequency-flat slowly Rayleigh fading channels are compared and it was proved and achieved to obtain less BER compared with MIMO-CDMA with less system complexity.

1. INTRODUCTION :

Application of parity bits in selecting the spreading codes in direct-sequence spread spectrum (DS-SS) systems is first introduced in [2]. In spread spectrum systems employing parity bits selected spreading codes (SS-PB), instead of appending the parity bits generated from a linear block encoder, they are used to select a spreading code from a set of mutually orthogonal spreading sequences [2]. Wireless communication systems in the next generation technologies are required to have high voice quality and also need to provide higher data rates. At the same time they need to operate in different types of environments also. In [1] the author has proposed maximal ratio receive combining scheme and he also proposed new transmit diversity scheme with two branch transmit diversity with one receiver and two branch diversity with M receivers. The scheme achieves full diversity for 2x2 antennas. In [3] MIMO-CDMA system performance is analyzed with Monte Carlo simulations. In[5] the author has designed space time block codes with real and imaginary cases. And STBC is designed with a matrix. And provides orthogonality among the symbols. In [7] author has designed MIMO-CDMA system with space time block codes. In this design permutation spreading method is used for selection of spreading sequence. And each user needs eight spreading sequences in this scheme. In [8] author has proposed multi-carrier CDMA system with STBC and QSTBC codes, and the system performance is improved by using constellation rotation. The extension of this work in MIMO-CDMA systems is discussed in [3], where two main techniques to select spreading waveforms are explained. In a MIMO-CDMA system employing parity bit selected spreading code, the calculated parity bits are used to choose a spreading waveform from a set of mutually orthogonal spreading codes to be used in all transmit antenna during that signaling interval. In contrast, in a system employing permutation spreading, each block of information bits assigns a different permutation of spreading waveforms to transmit antennas[3]. The impressive performance of turbo (iterative) processing techniques that soon followed the discovery of turbo codes [4] has inspired many researchers to utilize the turbo principle in a variety of ways in the architecture of the receiver. The application of turbo processing in MIMO systems has been discussed in the literature, and turbo processing techniques have been shown to attain a channel capacity close to the Shannon limit [5,6]. More recent works such as [7] have investigated the iterative joint channel estimation and data detection for MIMO-CDMA systems. In this paper, we introduce a new turbo receiver for MIMO-CDMA systems that employ parity bit selected and permutation spreading. To be able to use turbo processing in the receiver, a serially concatenated convolutional encoder is used in the transmitter. In this system, the parity bit selected or permutation spreading techniques act as an inner code without allocating any transmit energy to the additional redundancy provided by these techniques [5]. The receiver implements a turbo processing by iteratively exchange soft information on coded bits between a soft-input soft-output (SISO) detector and a SISO decoder. In this system, detection is performed by incorporating the *extrinsic* information provided by the decoder in the last iteration into the received signal to calculate the likelihood of each detected bits in terms of log likelihood ratios (LLR) which are used as the input for a SISO decoder. In the case of multiple user systems, a turbo multiuser receiver is presented in which multiple access interference (MAI) affecting each user is estimated based on the *extrinsic* information of all other user in the system. Simulation results presented in this paper show a significant improvement in the performance of MIMO-CDMA systems of both parity bit selected and permutation spreading when a turbo receiver is implemented. Similar iterative detection strategies have been studied for a single carrier as well as multicarrier SS-PB systems in [8] and [9], respectively.

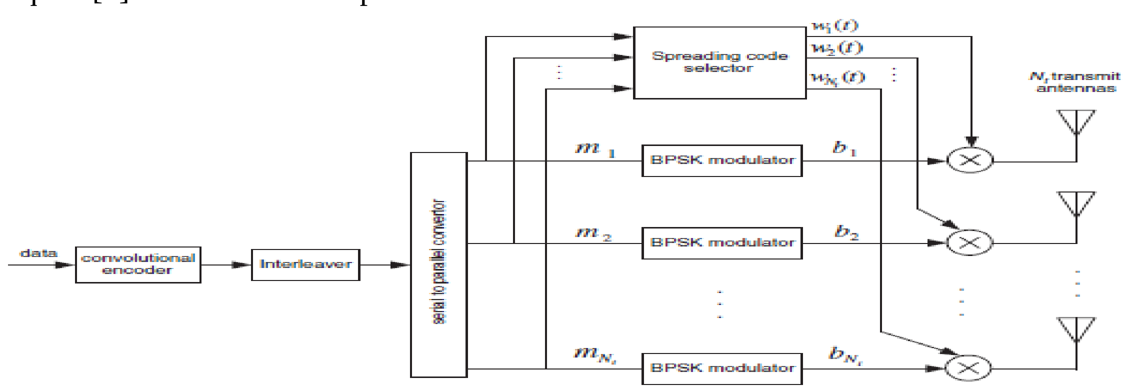

Figure 1: Transmitter of a coded MIMO-CDMA system employing parity bit selected and permutation spreading.

2. T-DESIGNS for MIMO – CDMA

MIMO-CDMA with Parity bit selected spreading is discussed in [2]. In parity bit selected spreading sequence technique, based on the calculated parity bits the spreading waveform is selected for each antenna. In this approach, for each user 2(n-k) spreading sequences will be assigned. Where *n-k* is the number of parity bits of the code. The system MIMO-CDMA with t-design permutation spreading is similar to parity bit selected spreading. In this technique, all possible message vectors are divided in to cosets and depending on which coset that messages comes then the corresponding permutation of spreading waveforms are assigned for each antenna in to groups. Now M is a set of all possible message vectors, contains 16 elements. M is divided into 8 possible cosets. The MIMO-CDMA system is designed with Nt=Nr=4 antennas, and N=8. On signaling interval, the message to be transmitted is {m1, m2,…mNt}.

The cosets are M1={0000 1111},M2={0001 1110}, M3={0010 1101}, M4={0011 1100} M5={0100 1011}, M6={0101 1010}, M7={0110 1001}, M8={0111 1000}.

And the spreading sequences are assigned to the antennas as shown in TABLE I. for example, if the message comes from M1, then spreading waveforms for four antennas are c1,c3,c5 and c7 correspondingly.

Coset	Message Vectors	$w_1(t)$	$w_2(t)$	$w_3(t)$	$w_4(t)$
M_1	0000 1111	$C_1(t)$	$C_3(t)$	$C_5(t)$	$C_7(t)$
M_2	0001 1110	$C_8(t)$	$C_1(t)$	$C_4(t)$	$C_5(t)$
M_3	0010 1101	$C_2(t)$	$C_4(t)$	$C_3(t)$	$C_8(t)$
M_4	0011 1100	$C_5(t)$	$C_2(t)$	$C_6(t)$	$C_3(t)$
M_5	0100 1011	$C_6(t)$	$C_7(t)$	$C_1(t)$	$C_4(t)$
M_6	0101 1010	$C_3(t)$	$C_6(t)$	$C_8(t)$	$C_1(t)$
M_7	0110 1001	$C_7(t)$	$C_8(t)$	$C_2(t)$	$C_6(t)$
M_8	0111 1000	$C_4(t)$	$C_5(t)$	$C_7(t)$	$C_2(t)$

Table 1: T-DESIGNS PERMUTATION SPREADING TABLE FOR 4 TRANSMIT ANTENNAS

3. SPACE-TIME BLOCK CODE APPROACH

The MIMO-CDMA system employing STBC permutation spreading [5] is shown in Fig 1. The input bit stream is converted into Nt parallel data streams. And these bits are given to spreading sequence selector that selects Nt spreading waveforms, then these data bits are modulated with BPSK modulation, then each bit is spread by using spreading waveform. On a given signaling interval Nt spreading waveforms will be selected from N orthogonal spreading waveforms. And at the receiver side, the output of each antenna is given to a bank of matched filters, and according to matched filter decision, the transmitted data is estimated.

The spreading assignment is done based on 8x8 STBC matrixes.

$$
\begin{bmatrix}
c_1 & c_2 & c_3 & c_4 & c_5 & c_6 & c_7 & c_8 \\
-c_2 & c_1 & c_4 & -c_3 & c_6 & -c_5 & -c_8 & c_7 \\
-c_3 & c_4 & c_1 & c_2 & c_7 & c_8 & -c_5 & -c_6 \\
-c_4 & c_3 & c_2 & c_1 & c_8 & -c_7 & c_6 & -c_5 \\
-c_5 & -c_6 & -c_7 & -c_8 & c_1 & c_2 & c_3 & c_4 \\
-c_6 & c_5 & -c_8 & c_7 & -c_2 & c_1 & -c_4 & c_3 \\
-c_7 & c_8 & c_5 & -c_6 & -c_3 & c_4 & c_1 & -c_2 \\
-c_8 & -c_7 & c_6 & c_5 & -c_4 & -c_3 & c_2 & c_1
\end{bmatrix}
$$

Here the columns of 1,5,8, and 6 of above matrix shown are assigned to columns 1,2,3,4

The received vector r = ub+n ,

Where r = [r_{11} r_{12} ,..., r $_{18}$,..., r_{21} ….r $_{41}$,..., r_{48} ,...,] and

n= [n_{11} ,n_{12} ,..., n_{18} ,..., n_{21} ,..., n_{41} ,..., n_{48}]

Where u_b is the received data vector that depends on the transmitted data vector without noise.

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And b = [b1,b2,b3,b4] in case of 4x4 antenna system. For example if m = [0,0,0,1] then b=[-1,-1,-1, 1].

Maximum likely hood detection is performed to detect the data. And squared Euclidean distance is found between the received vector and all other possible received vectors and the value which is minimum will be taken as the transmitted message

$$b=\min_b // r-u_b //^2$$

The above expression finds the squared Euclidean distance between the received vector and all possible remaining vectors and the vector which gives the smallest distance that is the transmitted message.

Coset	Message Vectors	$w_1(t)$	$w_2(t)$	$w_3(t)$	$w_4(t)$
M_1	0000 1111	$C_1(t)$	$C_5(t)$	$C_8(t)$	$C_6(t)$
M_2	0001 1110	$C_2(t)$	$C_6(t)$	$C_7(t)$	$C_5(t)$
M_3	0010 1101	$C_3(t)$	$C_7(t)$	$C_6(t)$	$C_8(t)$
M_4	0011 1100	$C_4(t)$	$C_8(t)$	$C_5(t)$	$C_7(t)$
M_5	0100 1011	$C_5(t)$	$C_1(t)$	$C_4(t)$	$C_2(t)$
M_6	0101 1010	$C_6(t)$	$C_2(t)$	$C_3(t)$	$C_1(t)$
M_7	0110 1001	$C_7(t)$	$C_3(t)$	$C_2(t)$	$C_4(t)$
M_8	0111 1000	$C_8(t)$	$C_4(t)$	$C_1(t)$	$C_3(t)$

Table 2: STBC PERMUTATION SPREADING TABLE FOR 4 TRANSMIT ANTENNAS

3. EXPERIMENTAL APPROACH

A MIMO-CDMA system using conventional method is given in [4]. It is a simple, easy to implement system, and does not use any space time coding technique. At the transmitter, each transmit antenna is assigned a unique spreading sequence, and all the information messages being transmitted by that antenna are spread by this spreading sequence. The transmitter model for the conventional MIMO-CDMA system is given at Figure 1. The input message bits are grouped and mapped into symbols by signal mapping. Then the symbols are converted into parallel data streams through a serial-to-parallel converter. The information data (SJ~SM) is directly multiplied with the spreading sequences {ci (t) ~CMt(t)) before transmission. A unique, orthogonal spreading sequence is assigned for each transmit antenna. If there are Nt antennas at transmitter; then, accordingly, Nt different spreading sequences are required. Parity bit selected spreading sequence technique, based on FEC block code, and was first proposed in [11]. In a CDMA system using (n,k) systematic block code, the calculated n-k parity bits are used to select a spreading sequence from a set of mutually orthogonal spreading sequences. Once the spreading sequence is selected, it is used to spread all k message bits in the block

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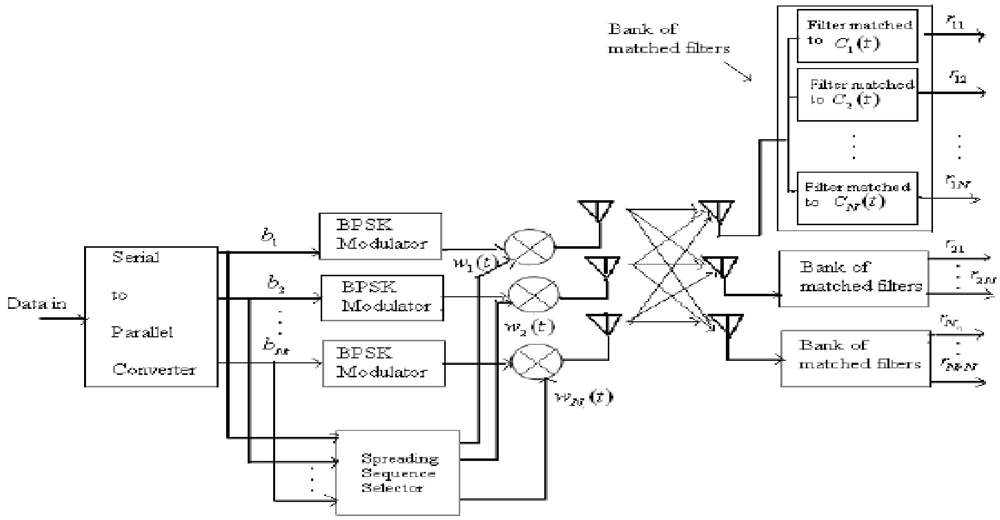

Figure 2: MIMO-CDMA system with STBC spreading permutation for 3 transmit and 3 receive antennas.

At the receiver, the system first determines which spreading sequence in the set was most likely employed by the transmitter by observing the magnitudes of the matched filter outputs over the duration of the block. Then, assuming the first step is correct; it determines the most likely transmitted message block by comparing the matched filters outputs to the subset of Messages that correspond to the selection of that spreading sequence. Since the parity bits are not appended at the end of information message bits, this technique can improve the system performance in the additive white Gaussian noise (AWGN) channel with no transmission rate loss. The transmitter model for the CDMA system using parity bit selected spreading, given in [11], When the receiving antenna is moved relative to the transmitter there will be temporary local minimum in the amplitude of the incoming electromagnetic wave. This is called fading. This will of course happened twice every wavelength in the standing wave scenario. This effect can be reduced by using two receiving antennas at a distance of quarter of a wavelength apart from each other. The receiver then checks from which antenna it gets the strongest signal and uses that one. This is called space diversity. Suppose a receiver has one antenna at point A in the Figure 1.1 below and one antenna at point B, it is obvious that the amplitude in the received signal from antenna B is much greater than the received signal from antenna A. It is also evident that there is a great advantage to be able to choose between these two antennas.

SIMULATION RESULTS

MIMO-CDMA system with 4 transmit and 4 receive antennas are considered in this proposed technique and existing techniques. Simulation results for BER (bit error rate) performances are presented for 4x4 antenna system. From Fig.3 we see that MIMO-CDMA system employing STBC permutation spreading giving the better BER performance as compared to t-designs method, and conventional spreading also taken as reference. And here the proposed technique outperforms the conventional and t-designs.

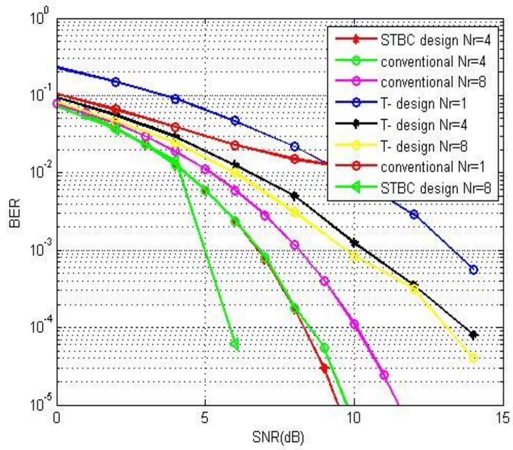

Figure 3: BER for STBC Permutation vs. T-Design Permutation

From TABLE I, we can see that in t-design permutation spreading table, there is no code symmetry between different co-sets, that leads to some degrees of freedom are lost, when MLD (maximum likelihood detection) is performed at the receiver. So that cause to slight increment of BER. But the system with STBC spreading, the permutation spreading table provides code symmetry between different co-sets, so that gives better BER performance.

CONCLUSIONS

Code division multiple access technology, has been widely used in mobile communications, because of its high spectrum efficiency, low transmit power. The T-designs Permutation Spreading method does not provide code symmetry so some sorts of degrees of freedom are lost in the squared Euclidean distance between different messages. The lack of code symmetry increases the BER. The STBC technique create dependency between the data streams and provide performance improvement compared to conventional spreading. All code symmetry also provides by using space-time block codes. Space–time block coding is a simple method for transmission using multiple transmit antennas in a wireless communication systems. STBC codes have a very simple maximum-likelihood decoding algorithm which is only based on linear processing. They provide full diversity given by transmit and receive antennas. Bit error rate performance also improves compared to the conventional and t-designs permutation spreading techniques.

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