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Performance Analysis of Spatial Modulation-Orthogonal Space-Time Block Coding

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Abstract - **Spatial modulation is a technique for transmission which uses multiple antennas. The fundamental strategy is used to map a block of information parts to a pair of information having units: 1) a symbol which was picked coming from a constellation diagram and 2) a unique transmit antenna number that was chosen from a set of transmit antennas. Here we apply SM to Orthogonal STBC transmission. Furthermore, we demonstrate that SM accomplishes much better overall performance in all researched channel conditions, in comparison with other techniques.**

Keywords - **Constellation diagram, SM, OSTBC.**

I. Introduction

Multiple–antenna technology innovation is really a loaded subject of research [1]. Inside sphere of those unfortunate remedies planned as of yet, Spatial Modulation (SM) is really a not long ago offered modulation program that assures some sort of low–complexity transmitter along with device pattern, in conjunction with enhanced program efficiency regarding quite a few state–of–the–art multiple–antenna answers. Subsequently, SM actually is an increased spectrally–efficient transmission technology with the similar signal price higher than one. Recent research have demonstrated that SM is capable of doing a higher capability when compared with multiple–antenna strategies along with comparable decoding complexity, such as Space–Time Block Codes (STBCs). Space–time block codes are designed to get the highest possible variety order for a given number of transmit and receive antennas subject to the restriction of having a simple decoding algorithm. Orthogonal space-time block codes (STBC's) have received considerable attention in recent open-loop multiple-input-multiple-output (MIMO) wireless communication literature because they allow low complexity maximum-likelihood decoding and guarantee full diversity.

II. Related Work

Many researchers have targeted their interest on a low complexness implementation of SM, which is known as Area Move Typing (SSK) modulation [2]. As opposed to SM, in SSK modulation only the spatial–constellation plan is used to regulate the information bits, thus trading–off transmitter and device complexness for the possible details amount [3]. As far receive– and transmit–diversity for SSK modulation is worried, the following contributions are available in the literary works. In [2] and [4], it is shown that SSK modulation can accomplish a receive–diversity gain that improves linearly with the variety of antennas at the device. In [5], it is proven that, regardless of the number of simultaneously–active antennas at the transmitter, SSK modulation is incapable to offer transmit–diversity profits. In [6], an easy technique is presented to get over that limitation. The remedy is appropriate to a transceiver with two transmit–antenna and one receive–antenna, and neither incurs in any spectral performance reduction nor needs multiple simultaneously–active antennas at the transmitter. In [7], transmit–diversity is obtained by delivering repetitive information in non–overlapping time–slots, thus running into in a spectral efficiency reduction. In [8], it is proven that the technique in [6] is incapable to offer full–diversity for an irrelevant variety of antennas at the transmitter and, in common, it allows us to achieve transmit–diversity only similar to two. In [9], the idea in [8] is prolonged and new methods to accomplish transmit–diversity higher than two are suggested. However, all these techniques are mainly worried with SSK modulation, while, to the best of the writers details, the style of transmit–diversity methods for the more common SM concept have never been regarded so far1. Only in

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[11], the writers have studied the possible transmit–diversity of SM and have indicated out that SM cannot accomplish transmit–diversity profits. However, no solutions are offered to deal with this problem and it is shown that the insufficient transmit–diversity may outcome, especially for high associated removal programs, in a significant performance loss of SM with regards to the program.
Organization: section III provides the primary SM system model. In section IV, we derive the Orthogonal Space-Time Block Codes, and offer an extensive look at its complexness. Section V provides simulation outcomes, and we concluded the paper in section VI.

III. Spatial Modulation

SM Transmission

The general system model is shown in Fig. 1, which consists of a MIMO wireless link with N_t transmit and N_r receive antennas. A random sequence of independent bits b enters the SM mapper, which groups $m = \log_2(MN_t)$ bits and maps them to a constellation vector $x = [x_1\, x_2 \ldots\ldots x_{N_t}]^T$, where we assume a power constraint of unity (i.e. Ex $[x^H x] = 1$). In SM, only one antenna remains active during transmission and hence, only one of the x_j in x is nonzero. The signal is transmitted over an $Nr \times Nt$ wireless channel H, and experiences an N_r −dim additive white Gaussian (AWGN) noise $\eta = [\eta_1\, \eta_2 \ldots\ldots \eta_{N_t}]^T$. The received signal is given by $y = \sqrt{\rho}Hx + \eta$, where ρ is the average signal to noise ratio (SNR) at each receive antenna, and H and η have independent and identically distributed (iid) entries according to $CN\,(0, 1)$.

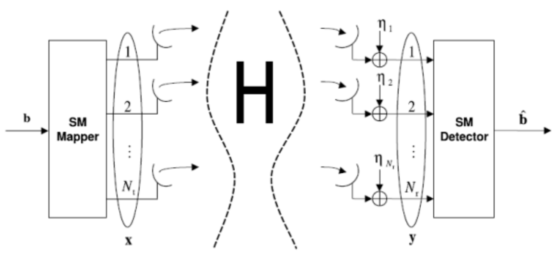

Figure1: Spatial modulation system model

As mentioned earlier, SM exploits the antenna index as an additional means to transmit information. The antenna combined with the symbol index make up the SM mapper, which outputs a constellation vector of the following form:

$$\mathbf{x}_{jq} \triangleq \begin{bmatrix} 0 & 0 & \cdots & \underset{j^{\text{th}}\text{ position}}{\underset{\uparrow}{x_q}} & 0 & \cdots & 0 \end{bmatrix}^T$$

Where j represents the activated antenna, and x_q is the q^{th} symbol from the M-ary constellation X. Hence, only the j^{th} antenna remains active during symbol transmission. For example, in 3 bits/s/Hz transmission with $N_t = 4$ antennas, the information bits are mapped to a ± 1 binary PSK (BPSK) symbol, and transmitted on one of the four available antennas. The output of the channel when x_q is transmitted from the j^{th} antenna is expressed as

$$y = \sqrt{\rho}\, h_j x_q + \eta \qquad (1)$$

Where h_j denotes the j^{th} column of H.

SM Detection (Sub-Optimal)

Sub-optimal detection rule based on MRC is given by

$$\hat{j} = \underset{j}{\arg\max}\; z_j \qquad (2)$$

$$\hat{q} = D\,(z_{\hat{j}}), \qquad (3)$$

Where $z_j = \frac{|h_j^H y|}{||h_j||_F^2}$, $\hat{j}$ and $\hat{q}$ represent the estimated antenna and symbol index, respectively, and D is the constellation demodulator function. Since the mapping is one to one, the demapper obtains an estimate of the transmitted bits by taking $\hat{j}$ and $\hat{q}$ as inputs. Now substituting (1) for y in (2) then z_j reduces to $\frac{\sqrt{\rho}|h_k^H h_j x_q|}{||h_k||_F^2}$ and, in order to detect the correct antenna index (i.e. $k = j$), we require $\frac{|h_k^H h_j|}{||h_k||_F^2} < 1$. By invoking Cauchy's inequality to the left hand side, we find that $||h_j||_F \leq ||h_k||_F$ is a necessary condition for antenna detection without errors, which should materialize in the absence of noise. One way to ensure this condition is by normalizing the channel prior to transmission

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(i.e. $||h_j||_F^2 = c$ for all j, where c is a constant). We refer to these channels as constrained.

IV. ORTHOGONAL STBC

An orthogonal STBC is characterized by a code matrix $G_{p\times n}$ where p denotes time delay or block length and n represents the number of transmit antennas. The entries of G are linear combinations of k data symbols or their conjugate, $s_1, s_2, \ldots, s_k, s_1^*, s_2^*, \ldots, s_k^*$ that belong to an arbitrary signal constellation. The columns of G are orthogonal to each other

$$G^{\varkappa} G = (|s_1|^2 + |s_2|^2 + \cdot \quad \cdot \quad \cdot + |s_k|^2) In \qquad (4)$$

Where $A^{\varkappa}$ denotes the complex conjugate transpose of matrix A, and In is the size-n identity matrix. The code rate of G is defined as R = k/p (i.e., each codeword with block length p carries k information symbols). To motivate the developments in this manuscript, consider as an example a communication system with two transmit and one receive antennas that utilizes the orthogonal STBC. If y_1 and y_2 denote the received signals at time slot 1 and time slot 2, respectively, then the received signal vector $[y_1 \ y_2]^T$ can be expressed as follows:

$$\begin{bmatrix} y_1 \\ y_2 \end{bmatrix} = \mathbf{G}_2(s_1, s_2) \begin{bmatrix} h_1 \\ h_2 \end{bmatrix} + \begin{bmatrix} n_1 \\ n_2 \end{bmatrix} \qquad (5)$$

Where $G_2\ (s_1, s_2) \triangleq \begin{bmatrix} s_1 & s_2 \\ -s_2^* & s_1^* \end{bmatrix}$ is the orthogonal STBC, $h1$ and $h2$ denote the channel coefficients from the two transmit antennas to the receive antenna, and $n1$, $n2$ represent additive complex Gaussian noise pertinent to time slot 1 and 2, respectively. Due to the special structure of **G**2(s1, s2), the received signal in (5) can be rewritten as

$$\begin{bmatrix} y_1 \\ y_2^* \end{bmatrix} = \begin{bmatrix} h_1 & h_2 \\ h_2^* & -h_1^* \end{bmatrix} \begin{bmatrix} s_1 \\ s_2 \end{bmatrix} + \begin{bmatrix} n_1 \\ n_2^* \end{bmatrix} \qquad (6)$$

It is interesting to note that in (6) the STBC structure is embedded in the channel matrix $\begin{bmatrix} h_1 & h_2 \\ h_2^* & -h_1^* \end{bmatrix}$, while the two data symbols appear as the elements of a 2 × 1 data input vector and the received signal at time slot 2, y_2, appears conjugated. The linear received signal expression in (6) is appealing as it is backward compatible with existing signal processing techniques and standards and allows, for example, the design of low complexity interference suppressing filters and channel equalizers.

V. SIMULATION RESULTS

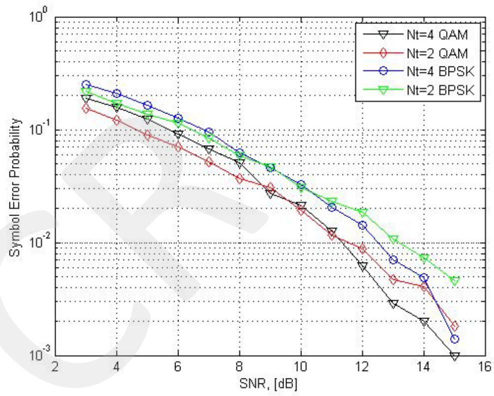

Figure2: Symbol Error Probability

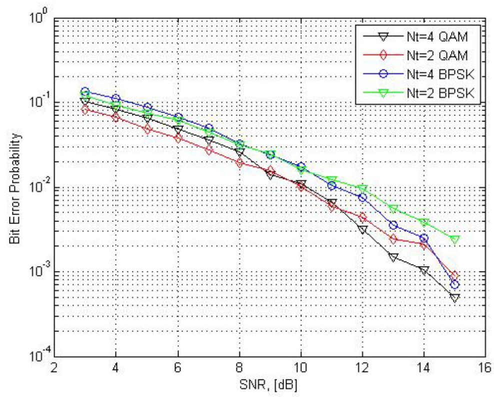

Figure2: Bit Error Probability

VI. CONCLUSION

STBC codes produce full transmit diversity but at the same time it's having less spectral efficiency. We have developed a trade off between spatial modulation and space time block coding. Combination of both schemes can produce a higher spectral efficiency and multiplexing gain of spatial modulation and improved BER.

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