Analysis of Space Time Frequency Coding in of dm Systems for Future Wireless Communications

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ABSTRACT: *- This paper investigates the different space-time codes for future wireless transmission. The considered space-time codes in the paper are Alamouti STBC, Golden STBC and Silver STBC, the performance of considered STBC's is studied in frequency selective fading channel with and without OFDM which provides a real communication environment and it has been observed that Golden STBC provides the best result among other considered STBC's.*

Keywords: *- Multiple-Input Multiple-Output (MIMO), Orthogonal Frequency Division Multiplexing (OFDM), Space Time Block Code (STBC), Channel State Information (CSI), Quasi-Orthogonal STBC (QO-STBC).*

I. INTRODUCTION

A Multiple-Input Multiple-Output (MIMO) wireless system uses multiple transmits and multiple receive antennas. The usage of multiple antennas provides a substantial increase in the capacity of the wireless system without requiring much increase in the system bandwidth. Nevertheless, it is anticipated that beyond third generation communication systems will still require large bandwidths to provide data rates of hundreds of megabits per second. Orthogonal Frequency Division Multiplexing (OFDM) I a digital multi-carrier modulation scheme, which uses a large number of closely-spaced orthogonal sub-carriers. OFDM also has the ability to simplify equalization dramatically in MIMO systems. This in turn enables support of more antennas and larger bandwidths. As such, the combination of OFDM modulation and MIMO technology is natural and beneficial. MIMO-OFDM [2] system is seen as the prime contender for the fourth generation wireless system. Early researches on MIMO-OFDM systems, however, are only applicable when the propagation channel is deterministically known, i.e. the system has perfect knowledge of the channel state information (CSI) at either the receiving or both transmitting and receiving ends of the communication link. Such requirement is probably a utopia for most wireless communication system. While perfect CSI approach results in over optimistic design, design requiring no CSI leads to rather pessimistic design. More recently, MIMO-OFDM schemes exploiting partial CSI have been proposed, encompassing the perfect CSI and no CSI paradigms. Partial CSI system requires some form of channel estimation capability. While there are already a lot of current researches on MIMO-OFDM channel estimation, there is very little development on channel estimation techniques that are based on power information.

Space-time coding [1] involves coding across space and time and is aimed at approaching the capacity limits of MIMO channels. Owing to their ability to multiply wireless capacity, mitigate slow fading, and facilitate new adaptive communications beyond the limits of conventional single-antenna wireless systems, MIMO and Space Time Coding techniques which combine coding, modulation and signal processing designs in systems employing multiple transmit-receive antennas have generated much research interest in recent years. Their adoption in cellular mobile radio, wireless LAN and wireless MAN standards have also marked their increasing significance in commercial broadband wireless systems.

An important class of space-time code is the Orthogonal Space-Time Block Code (O-STBC), which is attractive for its low decoding complexity, low decoding latency, and ability to provide full transmit diversity for mitigating slow fading by requiring multiple antennas only at the base stations or access points. However O-STBC suffers from low code rate when used with more than 2 transmit antennas and complex modulation. This rate disadvantage can be alleviated by a class of group-decodable STBC design called the Quasi-Orthogonal STBC (QO-STBC). The decoding complexity of QO-STBC is higher than that of O-STBC, but it can be capped by proper code design. The most popular space time code is the Alamouti [3] space time code. The transmissions in the Alamouti scheme are orthogonal. This implies that the receiver antenna „„sees"" two completely orthogonal streams. Hence, we obtain a transmit diversity of two. The other space time codes with full rate gain considered in the paper are Silver [4] space time code and Golden [5] space time code. The performance analysis of considered STBC"s is done with and without OFDM.

II. SYSTEM MODEL

In this paper the downlink communication with two transmit antennas ($MT = 2$) at the base station and two receiving antennas ($MR = 2$) at

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the terminal is considered. Figure 1 depicts the transmitter modules. Information bits *bk* are first channel encoded with a encoder of coding rate *R*. The encoded, interleaved bits are then fed to a phase shift keying module further complex symbols are encoded through a space time (ST) block code (STBC) encoder and transmitted during *T* symbol durations according to the chosen ST scheme. The ST coding rate is then defined by $L = Q/T$. With *MT* transmitting antennas, the output of the ST encoder is an (*MT*,*T*) matrix X = [*xi*,*t*] where *xi*,*t* (*i* = 1,…,*MT*; *t* = 1,…,*T*) is a function of the input symbols *sq* (*q* = 1,…,*Q*) depending on STBC encoder type. The resulting symbols are then fed to OFDM modulator of *N* subcarriers.

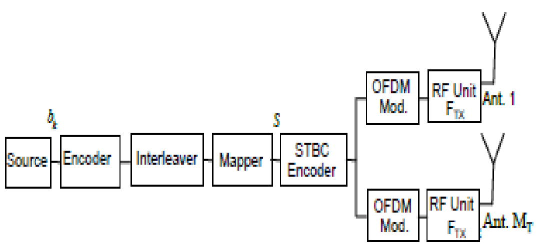

Figure 1- *Block diagram of the transmitter*

After D/A conversion, the signal is transposed to the transmitter carrier frequency FTX by the RF unit, and transmitted through the channel. At the receiver, it is transposed to base band with the receiver carrier frequency FRX and sampled at sampling frequency $F\tilde{e} = 1/Ts$.

Let us now describe the transmission link with a general model independently of the ST coding scheme. We separate the real and imaginary parts of the complex symbols input vector **s** {*sq*: *q* = 1,…,*Q*}, of the outputs X of the double layer ST encoder as well as those of the channel matrix H**,** and the received signal Y. In this work, we use an iterative receiver for non-orthogonal schemes where the ST detector and channel decoder exchange extrinsic information in an iterative way until the algorithm converges. The iterative detection and decoding exploits the error correction capabilities of the channel code to provide improved performance. The estimated symbols at the first iteration are obtained via minimum mean square error (MMSE) filtering

III. CONSIDERED SPACE-TIME SCHEME

The simplest orthogonal space-time coding scheme by Alamouti [2] is considered as a reference with *MT* = 2 and *MR* = 2. This code is given as

$$X = \begin{bmatrix} s_1 & s_2 \\ -s_2^* & s_1^* \end{bmatrix} \quad (3)$$

Another space-time coding scheme considered is Silver code [4] which is full rate and full diversity code for *MT* = 2 and *MR* = 2. The code is given as

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$$X = \begin{pmatrix} s_1 & -s_2^* \\ s_2 & s_1^* \end{pmatrix} + V\begin{pmatrix} s_3 & -s_4^* \\ s_4 & s_3^* \end{pmatrix}$$

here

$$V = \frac{1}{\sqrt{7}}\begin{pmatrix} 1-i & 1-2i \\ 1+2i & -1-i \end{pmatrix}$$

The other considered code is the Golden code [5] which is designed to maximize the rate such that the diversity gain is preserved for an increased signal constellation size. It is also defined for *MT* = 2, and *MR* = 2, the code is given as

$$X = \frac{1}{\sqrt{5}}\begin{bmatrix} \beta(s_1+\theta s_2) & \beta(s_3+\theta s_4) \\ \mu\overline{\beta}(s_3+\overline{\theta} s_4) & \overline{\beta}(s_1+\overline{\theta} s_2) \end{bmatrix} \qquad (6)$$

here

$$\theta = \frac{1+\sqrt{5}}{2}, \overline{\theta} = 1-\theta, \beta = 1+j(1-\theta),$$

$$\overline{\beta} = 1+j(1-\overline{\theta}),\ \mu = j \text{ and } j = \sqrt{-1}$$

IV. SIMULATION RESULTS

In this section, a comparative study of the considered space-time coding schemes is done. The performance comparison is made for a frequency selective channel with independent Gaussian distributed coefficients. It is computed in terms of symbol error rate (SER) versus signal to noise ratio (SNR) applying binary phase shift keying (BPSK) modulation scheme. Figure 2 shows the SER performance comparison of Golden STBC and Alamouti STBC systems for *MT* = 2 transmit antennas and *MR* = 2 receive antennas over frequency selective channel. The constellation used is BPSK. As shown in figure, the Golden STBC outperforms the Alamouti STBC by ≈ 3 dB at a SER of 10-1.

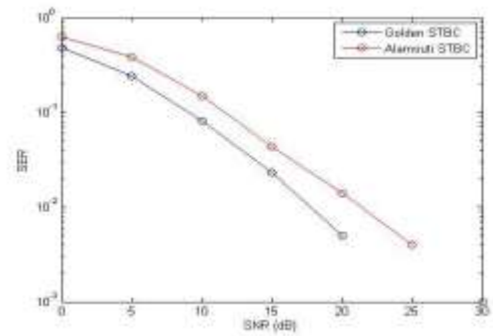

Figure 2- *SER Performance Comparison of the Golden STBC to the Alamouti STBC*

Figure 3 shows the SER performance comparison of Silver STBC and Alamouti STBC systems for *MT* = 2 transmit antennas and *MR* = 2 receive antennas over frequency selective channel. The constellation used is BPSK. As shown in figure, the Silver STBC outperforms the Alamouti STBC by ≈ 2 dB at a SER of 10-1.

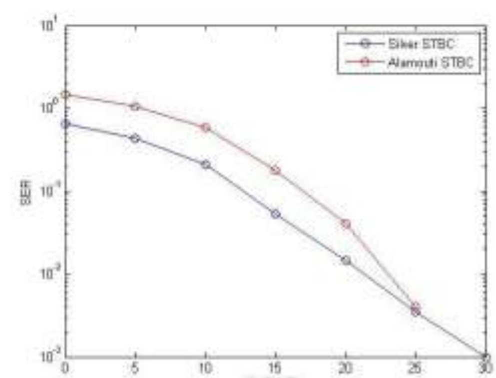

Figure 3- *SER Performance Comparison of the Silver STBC to the Alamouti STBC*

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Figure 4 shows the SER performance comparison of Golden STBC with OFDM and Alamouti STBC system with OFDM for $MT = 2$ transmit antennas and $MR = 2$ receive antennas over frequency selective channel. The constellation used is BPSK. As shown in figure, the Golden STBC outperforms the Silver STBC by ≈ 4.5 Db at a SER of 10-1.

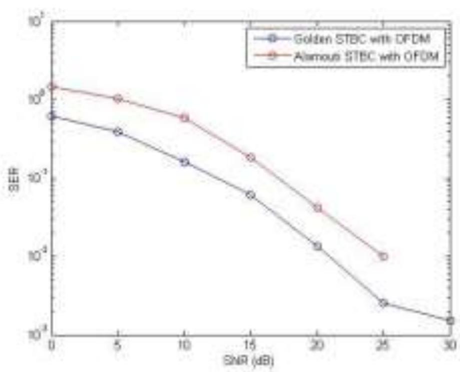

Figure 4- *SER Performance Comparison of the Golden STBC with OFDM to the Alamouti STBC with OFDM*

V. CONCLUSION

In this paper, an investigation of the different space time codes is considered and it has been observed that the Golden space time code outperforms all other considered space time codes thus providing the best results.

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