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Study and Simulation of Quasi Orthogonal Space Time Block Codes in MIMO systems for Rician Fading Channel

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Abstract— In this paper, we simulated two quasi-orthogonal space-time block codes (QOSTBCs) with three time slots for two transmit antennas and compared the SER vs SNR performance of two quasi-orthogonal space-time block codes (QOSTBCs) with three time slots for16 QAM ,for Rician and Rayleigh fading channel.The decoding scheme used is ML. We find that codes are having good performance.

Keywords— Orthogonal space-time block codes (OSTBCs), Quasi-orthogonal space-time block codes (QOSTBCs), Quasiorthogonal space-time block codes with 3 time slots (3-TS-QOSTBCs), Maximum-likelihood (ML) decoding, symbol error rate (SER), Long term evolution-Advanced (LTE-A).

I. INTRODUCTION

Diversity is the technique used in wireless communications systems to improve the performance over a fading radio channel, simple transmit diversity scheme was given by Alamouti[1],which used two transmit antennas to combat flat fading by increasing diversity at the receiver while maintaining the same transmission rate as on a single transmit antenna.

Alamouti[1] scheme was generalized by V.Tarokh[2],to any number of transmit and receive antennas using theory of orthogonal designs, which provide full diversity and have simple maximum- likelihood (ML) decoding that decouple every transmitted symbol at the receiver. Relaxing the constraint of orthogonality, many QOSTBcs have been presented [3], [4], [9] that provide partial diversity, full rate and linear ML decoder that decouples the pair of transmitted symbols instead of single symbol.

Alamouti scheme has very high importance for uplink transmission for a next generation wireless system, which is called Long Term Evolution-Advanced (LTE-A) [1], [14].

However, it is difficult to implement an OSTBC in the LTEA frame structure, because even numbers of time slots are normally not available for data transmission.

In many cases, there are 3 time slots available for data transmission, instead of 2 time slots as required by the orthogonal Alamouti scheme for two antennas.

Therefore, research has been focused on STBCs with 3 time slots for two transmit antennas. In [2], a scheme has been proposed which combines 2-time-slot Alamouti STBC with conventional transmit diversity scheme of symbol repetition The scheme requires a linear decoding at the receiver. However, it does not provide full-diversity due to the 3rd-time-slot symbol repetition. We call this scheme as AL scheme/code in the rest of this paper.

In [13], a full- rate full-diversity QOSTBC with 3 time slots (3TS-QOSTBC) and two transmit antennas has been presented. However, its decoding requires a pair-wise detection of two symbols.

Few full-rate or even higher rate and full-diversity 3TS-QOSTBCs have been proposed in [11] for two transmit antennas. In this paper, we are having SER VS SNR for 3-TS-QOSTBCs for two transmit antennas for 16 QAM modulations. In section II we have system model and brief overview of 3TS-QOSTBCs for two transmit antennas..Simulation results and conclusion are presented in section III and IV respectively.

II. SYSTEM MODEL AND REVIEW OF QOSTBCS WITH 3 TIME-SLOTS

A. System Model

We consider a wireless communication systems with 2 transmit and 1 receive antenna. Signal received by receive antenna at time-slot t is given by

$$r_t = \sum_{i=1}^{2} h_i c_t^i + \eta_t \qquad (1)$$

$$1 \le i \le 2, 1 \le t \le 3$$

Where η_t are noise samples. The coefficients hi are the path gains from i^{th} transmit antenna to the receive antenna. These path gains do not change during a codeword but may vary from one codeword to another codeword therefore the channel is quasi- static flat Rayleigh fading channel. C_t^i is the transmitted code symbol from i^{th} transmit antenna at time-slot t. From (1), received signal vector at the receive antenna can be written as are channel vector, complex white

Gaussian noise vector and received signal vector of the receive antenna, respectively.

$$R = ch + \eta \qquad (2)$$

Where

$$C = \begin{pmatrix} c_1^1 & c_1^2 \\ c_2^1 & c_2^2 \\ c_3^1 & c_3^2 \end{pmatrix} \qquad (3)$$

is the QOSTBC and

$$\begin{aligned} h &= (\mathrm{h}_1\ \mathrm{h}_2)^T \\ \eta &= (\eta_1\ \eta_2\ \eta_3)^T \\ R &= (\mathrm{r}_1\ \mathrm{r}_2\ \mathrm{r}_3)^T \end{aligned} \qquad (4)$$

Where superscript '*T*' in (4) represents the matrix transpose operation. Equation (2) can be rewritten as

$$R = HX + \eta \qquad (5)$$

Where X is the transmitted signal vector and *H* is defined as channel matrix corresponding to the receive antenna and both of them depend upon used QOSTBC.

$$H = \begin{pmatrix} H_{11} & H_{12} & H_{13} \\ H_{21} & H_{22} & H_{23} \\ H_{31} & H_{32} & H_{33} \end{pmatrix}$$

$$X = (\mathrm{x}_1\ \mathrm{x}_2\ \mathrm{x}_3)^T \qquad (6)$$

Where *Ht,s,*$1 \le t \le 3,\ 1 \le s \le 3$ is the channel path gain Corresponding to symbol *xs,* $1 \le s \le 3$ transmitted at timeslot t. *R* and□□in equation (5) can be obtained from *R* and □ □in equation (4) by simple processing such as conjugating few elements.

B. Review of QOSTBCs with 3 Time-Slots

In this Section, we briefly review existing QOSTBCs with three time slots and two transmit antennas. First 3TS-QOSTBC was proposed in [2] for two transmit antennas

$$X_{AL} = \begin{pmatrix} x_1 & x_2 \\ -x_2^* & x_1^* \\ x_3 & x_3 \end{pmatrix} \qquad (7)$$

We can observe from above code that it utilizes Alamouti scheme for the first two time slots, however, for the third timeslot, same symbol is transmitted by both antennas. Few other 3TS-QOSTBCs for two transmit antennas have been proposed in [11] and [13].

Two additional codes in the same category and corresponding decoders are proposed in [10].

1) Code i:

$$Q_1 = \begin{pmatrix} x_1 & \dfrac{x_2 + x_3}{\sqrt{2}} \\ \dfrac{(x_2 + x_3)^*}{\sqrt{2}} & -x_1^* \\ \dfrac{(x_2 - x_3)^*}{\sqrt{2}} & 0 \end{pmatrix} \qquad (8)$$

1) Code ii:

$$Q_2 = \begin{pmatrix} x_1 & \dfrac{x_2 + x_3}{\sqrt{2}} \\ \dfrac{(x_2 + x_3)^*}{\sqrt{2}} & -x_1^* \\ (x_2 - x_3)^* & 0 \end{pmatrix} \qquad (9)$$

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III. SIMULATION RESULTS

Computer simulation results of 3TS-QOSTBC codes [10] are shown in figure. Fig. 1 shows SER performance curves of Alamouti code [8], AL code [2] and our codes for 16-QAM modulation and Rician fading channel. Similarly, Fig. 2, shows SER performance curves of Alamouti code [8], AL code [2] and our codes for 16-QAM modulation and for Rayleigh fading channel.

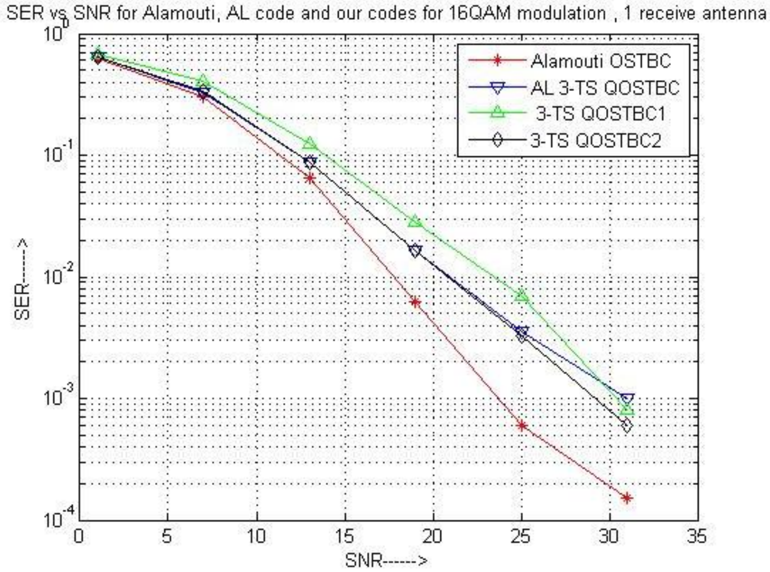

Figure:1 SER Performance Comparison for Rician fading channel

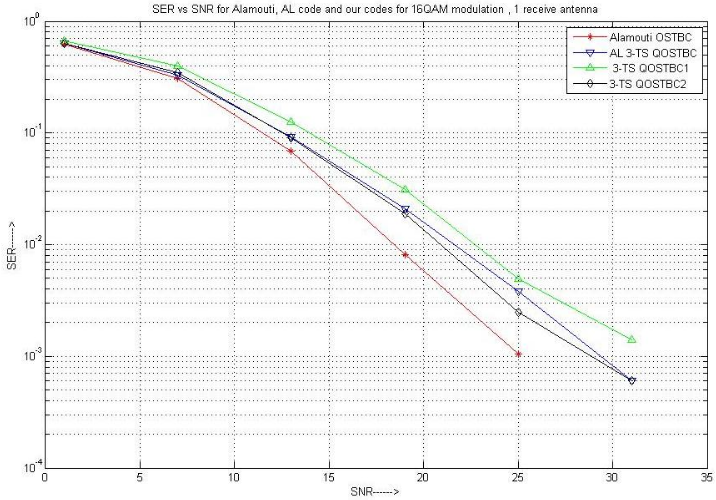

Figure:2 SER Performance Comparison for Rayleigh fading channel

IV. CONCLUSIONS

We evaluate the SER vs SNR for QOSTBC with 3 time slots for two transmit antennas and one receive antenna in frequency - flat quasi-static Reyleigh fading channel and Rician fading channel for 16 QAM. In both fading channel our codes[10] are having good performance with AL code [2] with ML decoding.

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