Abstract: In this paper, we proposed a space–time code selection technique for multiple transmit antenna OFDM systems and a constant-rate transmission mode for the space–time code selection technique is introduced. One important problem arises in case of MIMO system is, how to code across space and time to obtain the maximum output (minimum BER). For AWGN fading channels, space–time block coding (STBC) is a recent breakthrough solution to this problem. Analysis will be done for an OFDM wireless communication system by using space time block code (STBC) at the transmitter end, and considering the effect and the wireless channel like AWGN fading. A comparison will be made for the above mentioned technique by using different modulation method i.e. BPSK and QAM. The expression for Bit Error Rate will be developed for different input SNR. Performance results will be evaluated numerically and graphically using the plots of BER vs. SNR and Constellation diagram.

Keywords: - STBC, MIMO, OFDM system, Multiple Input Multiple Output System, AWGN, Fading, PSK, QAM, BER.

I. INTRODUCTION

MIMO stands for multiple inputs and multiple outputs. MIMO is the current theme for the international wireless research. The feasibility of implementing MIMO system and the associated signal processing algorithms is enabled by the corresponding increase of the computational power of integrated circuits, which is generally believed to grow with time in an exponential fashion [1, 3]. Fig 1 shows a MIMO wireless communication system which contains multiple antennas at both the transmitter and receiver.

MIMO technology has attracted attention in wireless communications, because:

1. It offers significant increases in data throughput and link range without additional bandwidth or transmit power.
2. It provides higher spectral efficiency (more bits per second per hertz of bandwidth).
3. It provides link reliability or diversity (reduced fading).

Because of these properties, MIMO is a current theme of international wireless research. MIMO takes the advantage of multi-path. “Multi-path” occurs when the different signals arrive at the receiver at various times. It uses multiple antennas to send multiple parallel signals (from transmitter). In an urban environment, these signals will bounce off trees, buildings, etc. and continue on their way to their destination (the receiver) but in different directions. With MIMO[5,6], the receiving end uses an algorithm or special signal processing to sort out the multiple signals to produce one signal that has the originally transmitted data.

Fig. 1 MIMO Communication System
II. SPACE TIME BLOCK CODING

Space-time code (STC) is a method usually employed into wireless communication systems to improve the reliability of data transmission using multiple antennas. STCs rely on transmitting multiple, redundant copies of a data stream to the receiver in the hope that at least some of them will survive the physical path between transmission and reception in a good state to allow reliable decoding[9]. Features of STC are:

1. STC provides the best possible tradeoff between constellation size, data rate, diversity advantages & trellis complexity.
2. It improves link reliability.
3. Increases system capacity through resource allocation.

In recent years, space-time coding techniques have received much interest. The concept of space time coding has arisen from diversity techniques using smart antennas. By using data coding and signal processing at both sides of transmitter and receiver, space-time coding now is more effective than traditional diversity techniques [2, 4]. Two main functions of STC are diversity & multiplexing. For maximum performance there should be trade off between diversity and multiplexing. Space can be divided in three types are:

1. Space Time Trellis Codes (STTCs)
2. Space Time Turbo Codes (STTuCs)
3. Space Time Block Codes (STBCs)

III. QAM (QUADRATURE AMPLITUDE MODULATION)

QAM, Quadrature amplitude modulation is widely used in many digital data radio communications and data communications applications. A variety of forms of QAM are available and some of the more common forms include 16 QAM, 32 QAM, 64 QAM, 128 QAM, and 256 QAM. Here the figures refer to the number of points on the constellation, i.e. the number of distinct states that can exist. The constellation diagrams (figure 2,3 and 4) show the different positions for the states within different forms of QAM, quadrature amplitude modulation. As the order of the modulation increases, so does the number of points on the QAM constellation diagram.

The diagrams below show constellation diagrams for a variety of formats of modulation:

<table>
<thead>
<tr>
<th>16QAM</th>
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<tbody>
<tr>
<td><img src="image1" alt="16QAM diagram" /></td>
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</table>

Fig. 2: 16 QAM constellation

<table>
<thead>
<tr>
<th>32QAM</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image2" alt="32QAM diagram" /></td>
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</table>

Fig. 3: 32 QAM constellation
IV. RELATED WORKS

Jungho Myung et. Al. [7] presents a symbol error rate (SER) study is presented for the dual-hop relay networks employing space–time block code (STBC) from coordinate interleaved orthogonal design (STBC-CIOD), where a relay with either a decode-and-forward (DF) or an amplify-and-forward (AF) protocol is equipped with multiple antennas. More specifically, the authors provide the union upper and lower bounds on the average SER by deriving an accurate closed-form formula for the corresponding symbol pairwise error rate (SPER). In addition, the asymptotic diversity order is analyzed. The theoretically derived bounds are in good agreement with the simulation results.

Sandipan Kundu et. al. [8] present a maximum-likelihood (ML) decoder with the lowest computational complexity known to-date for full-diversity, arbitrary size Quasi-Orthogonal Space-Time Block Codes (QO-STBCs) with symbols from square or rectangular quadrature amplitude modulation (QAM) constellations. The authors start with the formulation of an explicit joint two-complex symbol decoder for general QO-STBCs with arbitrary complex symbols and then derive the proposed ML decoder for QOSTBCs with QAM symbols. The complexity savings are made possible by a simplified quadratic ML decoding statistic that utilizes algebraically the structure of the signal points of the QAM constellation. Comparative computational complexity analysis with existing ML implementations and simulation studies are included herein for illustration and validation purposes.

Antonis Phasouliotis et. Al. [4] analyze and compare the error rate performance of downlink coded multiple-input multiple-output (MIMO OFDMA) and coded MIMO orthogonal frequency division multiple access (MIMO MC-CDMA) systems under frequency selective fading channel conditions. In particular, the pairwise error probabilities (PEP) for both systems are derived. Simulation results illustrate that when the number of users, hence the system load is low, MIMO MC-CDMA outperforms MIMO OFDMA. However, when the system load increases, the performance of MIMO MC-CDMA deteriorates and becomes worse than MIMO OFDMA. This can be explained by the PEP analysis of MIMO MC-CDMA which shows that when the number of users is small, the multiuser interference is also small and frequency diversity is better exploited. Conversely at high system load, MIMO OFDMA outperforms MIMO MC-CDMA as it is insensitive to multiuser interference. Nevertheless if the other users’ spreading sequences are available at the receiver of the desired user, the impact of multiuser interference can be minimized and MIMO MC-CDMA outperforms MIMO OFDMA at all system loads.

Jae-Shin Han et. Al. [10] presents multi-input multi-output orthogonal frequency division multiplexing (MIMO-OFDM) systems with dual-polarized division multiplexing (PDM) and diversity for multimedia broadcasting services. In particular, the polarized diversity is realized by transmitting two independent and distributed space-frequency coded signals through two sets of dual-polarized transmit antennas. In the corresponding polarized receptions, MIMO zero-forcing (ZF) detection and ZF detection combined with a group-wise or a symbol-wise successive cancelation (SIC) are used to minimize a depolarization effect caused by a cross-polarization discrimination (XPD). Furthermore, the authors analyze the output signal-to-interference-plus-noise ratio (SINR) of such MIMO detections in terms of the XPD effect. It is shown that the output SINR of MIMO ZF detection increases as the absolute XPD value increases. It is also shown that the output SINR of ZF-SIC detection converges to that of ZF detection as the absolute XPD value increases. Finally, the authors compare the performances of uni-polarized and dual-polarized MIMO-OFDM systems over a multipath Rician channel with XPD. From simulation results, the authors conclude that as the absolute XPD value increases, the polarized MIMO-OFDM systems provide a lower symbol error rate than uni-polarized MIMO-OFDM systems.

Fig. 4: 64 QAM constellations
V. PROPOSED METHODOLOGY

To implement the design of a STBC-OFDM wireless communication system MATLAB R2008a has been used as an implementation platform. Also, performance of the design will be evaluated by using same platform. Various steps that has been used to implement the above mentioned design are as follows:

- Declaration of variables like number of bits, number of subcarriers, levels of FFT, number of constellations, number of cyclic prefixes and input SNR
- Generation of binary data Construct an object to modulate binary data using PSK and QAM depending on number of constellation and type of input data.
- Modulation of data on modulator and conversion of data from serial to parallel.
- Grouping of data bits at size of 8 and then division of grouped bits into size of 4.
- Formation of 2 data symbol matrix i.e. x1 and x2 and Calculation of complex conjugate of both matrix bits so as to form imaginary part of data bits which will be orthogonal from their data bits.
- Designing of OFDM transmitter so as to transmit the data depending on level of FFT, number of cyclic prefixes and number of bits.
- Transmission and Designing of transmission channel depending on number of bits and number of subcarriers. Designing of Additive White Gaussian Noise. Then, Designing of receiver.
- Reception of data with removal of all additional guard and pilot bits.
- Construction of an object to demodulate binary data using PSK and QAM depending on number of constellation and type of input data.
- Calculation of number of errors by comparing transmitted and received data and Calculation of BER by using number of errors.
- Plotting of curve indicating value of BER at each input SNR value, plotting of Transmitted signal mapping Constellation and Plotting of Number of errors at each input SNR value.
VI. RESULTS

All the simulation has been performed on MATLAB R2012a. Three MIMO-STBC-OFDM wireless communication systems i.e. 16 PSK, 16 QAM and 64QAM have been designed. With input parameter as follows:

For 16 PSK
numbr_bits = 16*10^3;
numbr_symbols = 4;
SNR = 8:2:22;
FFT_level = 4;
Constellation = 16;
cyclic_prefix = 2;

For 16 QAM
numbr_bits = 16*10^3;
numbr_symbols = 4;
SNR = 8:2:22;
FFT_level = 4;
Constellation = 16;
cyclic_prefix = 2;

For 64 QAM:
numbr_bits = 16*10^3;
numbr_symbols = 4;
SNR = 8:2:22;
FFT_level = 4;
Constellation = 64;
cyclic_prefix = 2;

Simulation has been carried out using these parameters respectively. Let First, take the case of 16-PSK MIMO-STBC-OFDM system. Two parameters i.e. Number of errors and BER have been taken to analyse the system. The maximum value of BER at input SNR 8dB is 0.2485dB. The minimum value of BER at input SNR 22dB is 0.0114dB. Also, the maximum number of errors at input SNR 8dB is 15822. The minimum number of errors at input SNR 22dB is 801. Figure no. 5 is showing the curve plot of BER vs. SNR. Figure no. 6 is showing the Bar plot of number of errors vs. SNR. Also, figure no. 7 is showing the mapping of input bits in 16QAM constellation.
In second case i.e. 16-QAM MIMO-STBC-OFDM system, the maximum value of BER at input SNR 8dB is 0.2181dB. The minimum value of BER at input SNR 22dB is 0.2104dB. Also, the maximum number of errors at input SNR 8dB is 14091. The minimum number of errors at input SNR 22dB is 13493. Figure no. 8 is showing the curve plot of BER vs. SNR. Figure no. 9 is showing the Bar plot of number of errors vs. SNR. Also, figure no. 10 is showing the mapping of input bits in 16QAM constellation.
In third case i.e. 64-QAM MIMO-STBC-OFDM system, the maximum value of BER at input SNR 8dB is 0.0101 dB. The minimum value of BER at input SNR 22dB is almost 0dB. Also, the maximum number of errors at input SNR 8dB is 890. The minimum number of errors at input SNR 22dB is 1. Figure no. 11 is showing the curve plot of BER vs. SNR. Figure no. 12 is showing the Bar plot of number of errors vs. SNR. Also, figure no. 13 is showing the mapping of input bits in 64QM constellation.
In this work, we have studied different estimation technique and found out that blind estimation is the best method to calculate coding in non-cooperative environment and it provide good performance with low cost and low computational complexity. Different detection techniques have been studied which provides good detection and found maximum likelihood decoding is the best technique to provide the optimum result with low signal to noise ratio. With the help of three ML classifier referred as optimal, SOS, CP and simulate the STBC recognition problem. First classifier is optimal in ideal sense but it is impractical when the communication parameters are unknown at receiver side. In blind sense, the SOS STBC provides good performance then CP classifier in low SNRs region, but this classifier requires the channel estimation. On the other hand there is no knowledge of parameter in CP classifier, which can distinguish different STBCs with code parameters and provide good performance with low cost.

REFERENCES


Marco Chiani, Senior Member, IEEE, Moe Z. Win, Fellow, IEEE, and Hyundong Shin, Member, IEEE, “MIMO Networks: The Effects of Interference” IEEE TRANSACTIONS ON INFORMATION THEORY, VOL. 56, NO. 1, JANUARY 2010.


Jungho Myung, Student Member, IEEE, Hoojin Lee, Member, IEEE, and Joonhyuk Kang, Member, IEEE, “Performance Analysis of a Dual-Hop Relay With STBC-CIOD over Rayleigh Fading Channels” IEEE TRANSACTIONS ON VEHICULAR TECHNOLOGY, VOL. 62, NO. 1, JANUARY 2013.

Sandipan Kundu, Weifeng Su, Member, IEEE, Dimitris A. Pados, Member, IEEE, and Michael J. Medley, Senior Member, IEEE, “Fastest-Known Maximum-Likelihood Decoding of Quasi-Orthogonal STBCs with QAM Signals”, IEEE WIRELESS COMMUNICATIONS LETTERS, VOL. 2, NO. 1, FEBRUARY 2013

Jiayi Zhang, Student Member, IEEE, Michail Matthaiou, Member, IEEE, George K. Karagiannidis, Senior Member, IEEE, Haibo Wang, and Zhenhui Tan, Member, IEEE, “Gallager’s Exponent Analysis of STBC MIMO Systems over $\eta$-\mu and $\kappa$-\mu Fading Channels” IEEE TRANSACTIONS ON COMMUNICATIONS, VOL. 61, NO. 3, MARCH 2013

Jae-Shin Han, Jong-Seob Baek, Member, IEEE, and Jong-Soo Seo, Senior Member, IEEE, “MIMO-OFDM Transceivers With Dual-Polarized Division Multiplexing and Diversity for Multimedia Broadcasting Services” IEEE TRANSACTIONS ON BROADCASTING, VOL. 59, NO. 1, MARCH 2013.