Performance Evaluation of STBC-OFDM System for Wireless Communication

Apeksha Deshmukh, Prof. Dr. M. D. Kokate

Department of E&TC, K.K.W.I.E.R. College, Nasik, apeksha19may@gmail.com

Abstract— In this paper the space-time block codes orthogonal frequency division multiplexing system is presented. The performances of the proposed design have been demonstrated through the simulation of an STBC-OFDM system with two transmits antennas and one receive antenna. It provides an accurate but hardware affordable channel estimator to overcome the challenge of multipath fading channels. The system uses Alamouti code with transmit and receive diversity. The implementation of system is done by using MATLAB simulation. The performance of BER for 64 QAM modulation scheme is simulated.

Keywords— Space-time block code, orthogonal frequency division multiplexing, channel estimator.

INTRODUCTION

Wireless communication is the fastest growing segment of the communication industry. It has captured the attention of the media and the imagination of the public. Many technical challenges remain in designing robust wireless networks that deliver the performance necessary to support emerging applications. In recent years, researchers have realized that many benefits as well as a substantial amount of performance gain of receive diversity can be reproduced by using multiple antennas at transmitter to achieve transmit diversity. In the early 1990's, development of transmit diversity techniques has started. Since then the interest in the topic has grown in a rapid fashion. In fact, we can expect MIMO technology [1] to be a cornerstone of many wireless communication systems due to the potential increase in data rate and performance of wireless links offered by transmit diversity and MIMO technology.

Orthogonal frequency-division multiplexing (OFDM) has become more popular during the last decades, because it provides a substantial reduction in equalization complexity compared to classical modulation techniques. The concept of OFDM is very simple but the practicality of implementing it has many complexities. OFDM depends on Orthogonality principle. Orthogonality means, it allows the sub carriers, which are orthogonal to each other, meaning that cross talk between co-channels is eliminated and inter-carrier guard bands are not required. The new standards rely on coherent quadrature amplitude modulation (QAM), and thus require channel estimation. Hence, the complexity of channel estimation is of crucial importance, especially for time-varying channels, where it has to be performed periodically or even continuously. For the coherent modulation schemes in the OFDM systems, the channel state information (CSI) is required to compensate channel distortion. It is based on an orthogonal frequency division multiple accesses (OFDMA) technique to support multiple access schemes are used to allow many users to share simultaneously a finite amount of spectrum. STBC-OFDM systems with multiple antennas can provide diversity gains to improve transmission efficiency and quality of mobile wireless systems [2], [3], but accurate CSI is required for diversity combining, coherent detection, and decoding. Moreover, the system performance is also sensitive to the synchronization error.

Various channel estimation methods have been proposed for OFDM systems. Among these methods, discrete Fourier transform (DFT)-based channel estimation methods using either minimum mean square error (MMSE) criterion or maximum likelihood (ML) criterion have been studied for OFDM systems with preamble symbols [4]. Since no information on channel statistics or operating signal-to-noise ratio (SNR) is required in the ML scheme, the ML scheme is simpler to implement than the MMSE scheme [4]. Furthermore, when the number of pilots is sufficient, the two schemes have comparable performances [5].

PROPOSED METHODOLOGY

A. OFDM TRANCEIVER:

Orthogonal Frequency Division Multiplexing (OFDM) is a multicarrier modulation technique. Multicarrier transmission is a method devised to deal with frequency selective channels. In frequency selective channels different frequencies experience disparate degrees of fading. The problem of variation in fading levels among different frequency components is especially aggravated for high data rate systems due to the fact that in a typical single carrier transmission the occupied bandwidth is inversely proportional to the symbol period. The basic principle of multicarrier transmission is to translate high rate serial data stream into several slower parallel streams such that the channel on each of slow parallel streams can be considered flat. Parallel streams are modulated on subcarriers.

In addition to that, by making symbol period longer on parallel streams the effect of the delay spread of the multipath channel, namely inter-symbol interference (ISI), is greatly reduced. In multipath channels multiple copies of the transmitted signal with different delays, which depend on characteristics of the material from which the transmitted signal has been reflected, are received at the receiver. The delay spread of a channel is a measure of degree of multipath effect. It is equal to the difference between arrival times of the first and the last multipath components. Due to the fact the length of the symbol period of each parallel stream scales proportionally to the number of subcarriers used the percentage of overlap between two adjacent symbols due to delay spread and resulting from it inter-symbol interference (ISI) also decreases proportionally to the number of subcarriers.

The signal generated is a base band, thus the signal is filtered, then stepped up in frequency before transmitting the signal. OFDM time domain waveforms are chosen such that mutual orthogonality is ensured even though sub-carrier spectra may overlap. Typically QAM or differential quadrature phase shift keying (DQPSK) modulation schemes are applied to the individual sub carriers. To prevent ISI, the individual blocks are separated by guard intervals where in the blocks are periodically extended.

B. SPACE-TIME BLOCK CODING:

Space-time block codes (STBC) are a generalized version of Alamouti scheme [2], but have the same key features. These codes are orthogonal and can achieve full transmit diversity specified by the number of transmit antennas. In other words, space-time block codes are a complex version of Alamouti's space-time code, where the encoding and decoding schemes are the same as there in the Alamouti space-time code on both the transmitter and receiver sides. The data are constructed as a matrix which has its columns equal to the number of the transmit antennas and its rows equal to the number of the time slots required to transmit the data. At the receiver side, the signals received are first combined and then sent to the maximum likelihood detector.

The different replicas sent for exploiting diversity are generated by a space-time encoder which encodes a single stream through space using all the transmit antennas and through time by sending each symbol at different times. This form of coding is called Space-Time Coding (STC). Due to their decoding simplicity, the most dominant form of STCs are STBC.

In a wireless communication system the mobile transceiver has a limited power and also the device is so small in size that placing multiple antennas on it would lead to correlation at the antennas due to small separation between them. To avoid this, the better thing to do is to use multiple transmit antennas on the base station and the mobile will have only one. This scenario is known as Multiple Input Single Output (MISO) transmit-diversity. A system with two transmit and one receive antenna is a special case and is known as Alamouti STBC. The Alamouti scheme is well known since it provides full transmit diversity. For coherent detection it is assumed that perfect channel state information is available at the receiver. Transmit diversity (TD) is an important technique to achieve high data rate communications in wireless fading environments. The most popular transmit-diversity scheme is the (2x1) Alamouti scheme where channel state information and the code used is known to the receiver.

Space-time block codes were designed to achieve the maximum diversity order for the given number of transmit and receive antennas subject to the constraint of having a simple linear decoding algorithm [6]. This has made space-time block codes a very popular and most widely used scheme.

C. ALAMOUTI CODE:

Alamouti system is one of the first space time coding schemes developed for the MIMO systems which take advantage out of the added diversity of the space direction. Therefore we need less bandwidth or less time. We can use this diversity to get a better bit error rate. At the transmitter side, a block of two symbols is taken from the source data and sent to the modulator [6]. Afterwards, the Alamouti space-time encoder takes the two modulated symbols, in this case x1 and x2 and creates an encoding matrix x where the symbol x1 and x2 are planned to be transmitted over two transmit antennas in two consecutive transmit time slots. The Alamouti encoding matrix is as follows:

$$\boldsymbol{X} = \begin{bmatrix} x_1 & x_2 \\ -x_2^* & x_1^* \end{bmatrix} \quad (1.1)$$

In the decoder, the received signal is fed to the channel estimator. The estimated coefficients of the channel together with the combiner are given as the input to the maximum likelihood detector. The detected signal is then fed to the demodulator. The demodulator gives the original information which is transmitted [6].

PROPOSED SYSTEM

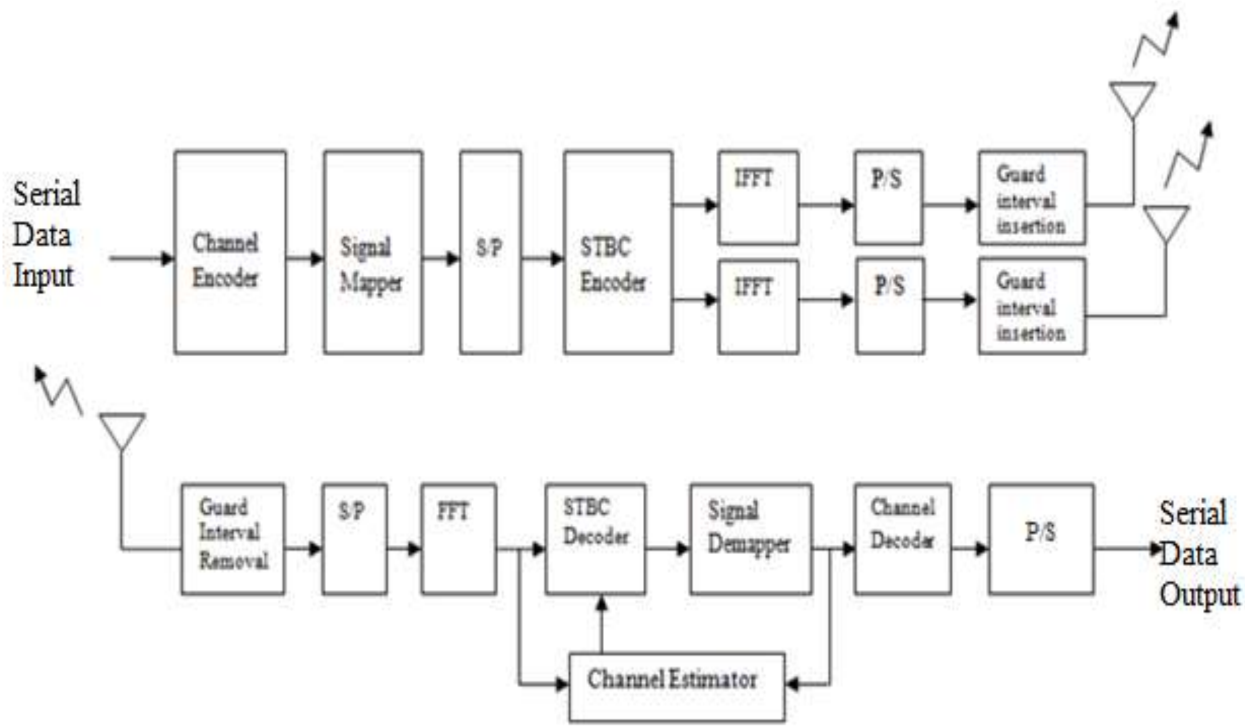

Figure.no.2: Proposed STBC-OFDM System

The receiver architecture consists mainly of a channel estimator along with other blocks. The channel is assumed to be quasi-static state within any two successive OFDM symbol durations. Therefore, without any loss, the signal processing of the received data is focused on each time slot, and the symbol time index is omitted hereafter except otherwise stated. The channel frequency response between the first transmit antenna and the receive antenna is denoted as $H^{(1)}[k]$, and the other one is denoted as $H^{(2)}[k]$ [3]. Within a time slot, after the received signals have passed through the guard interval removal and the N-point fast Fourier transform (FFT), the two successive received OFDM symbols R[1-k], and R[2-k], are given by

$$R[1,k]=H^{(1)}[k]X_F[k]+H^{(2)}[k]X_S[k]+Z[1,k] \quad (1.2)$$

$$R[2,k]=-H^{(1)}[k](X_S[k])^{*}+H^{(2)}[k](X_F[k])^{*}+Z[2,k] \quad (1.3)$$

The channel estimator is work on two stages. An initialization stage uses a multipath interference cancellation (MPIC)-based decorrelation method to identify the significant paths of CIR in the beginning of each frame. However, the CIR estimated by the preamble cannot be directly applied in the following data bursts since the receiver is mobile. Thus, a tracking stage is then used to track the path gains with known CIR positions. In the initialization stage, the significant paths are identified during the preamble symbol time. In the tracking stage, the path gain variations in the identified path positions will be tracked.

SIMULATION & RESULTS

In this system we use the Alamouti code for OFDM transmitter and receiver. The implementation of proposed system is in the MATLAB software. Performance of BER for 64 QAM is shown with different schemes like SISO, SIMO, MISO, MIMO schemes in STBC-OFDM receiver. There are three iterations where the value of bit error rate of system is evaluated. If the value of SNR is increases then less bit error rate is obtained.

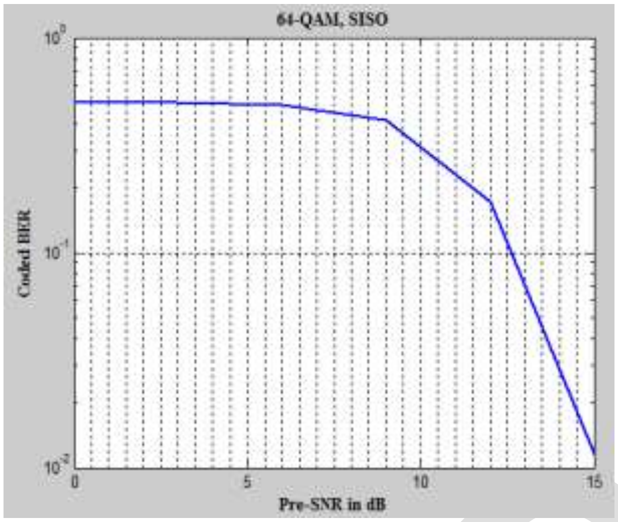

Figure.no.3 BER VS SNR SISO

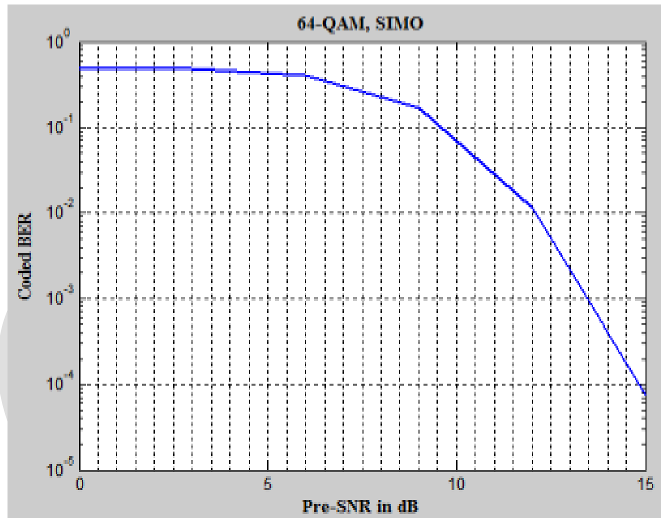

Figure.no.4 BER VS SNR SIMO

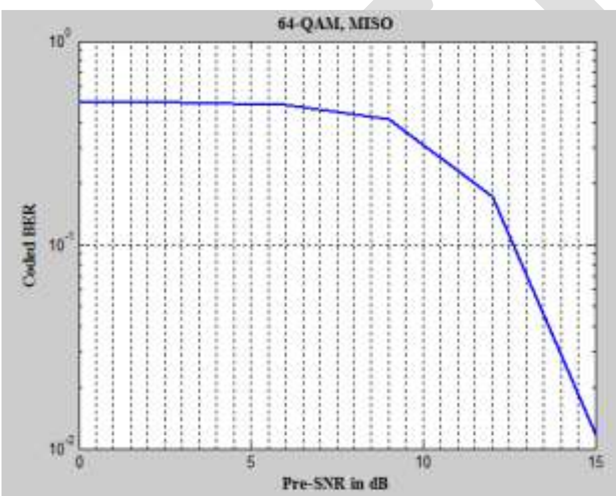

Figure.no.5 BER VS SNR FOR MISO

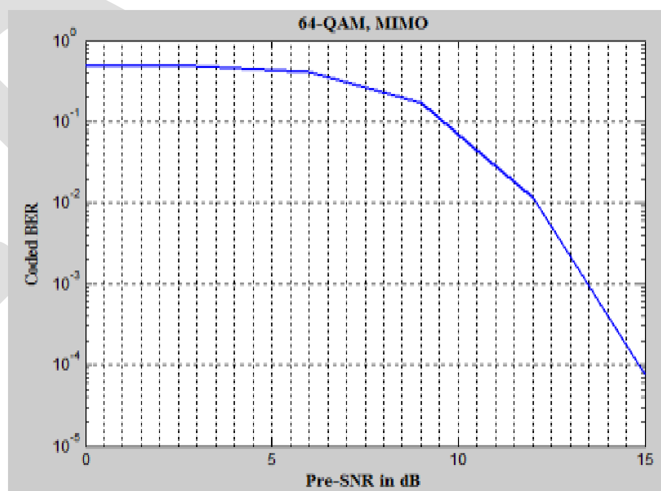

Figure.no.6 BER VS SNR MIMO

CONCLUSION

This paper gives a basic overview of the Space-Time Coding has been provided by presenting Alamouti's scheme. The system consist of two transmits antennas and one receive antenna. It provides an accurate but hardware affordable channel estimator to overcome the challenge of multipath fading channels**.** We can increase the number of antennas at both transmitter and receiver without introducing any interference in between the antennas. The better BER curve produced by system which uses more number of antennas at both sides of the communication link. A particular application decides which modulation can be used. However, in mobile technology, the bit error rate is very important. In this case, accuracy is essential. Therefore, lower order modulation methods are usually employed. The STBC which includes the Alamouti Scheme as well as an orthogonal STBC for 2 transmit antenna and 1 receive antenna case has been simulated and studied. Performances of BER for 64 QAM schemes are plotted.

REFERENCES:

[1] Daniel W. Bliss, Keith W. Forsythe, and Amanda M. C "MIMO Wireless Communication ", Lincoln Laboratory Journal , Vol.15, No.1, 2005.

[2] S. M. Alamouti, "A simple transmit diversity technique for wireless communications," *IEEE J. Select. Areas Commun.*, vol. 16, no. 8, pp. 1451–1458, Oct. 1998.

[3] M. L. Ku and C. C. Huang, "A complementary codes pilot-based transmitter diversity technique for OFDM systems," *IEEE Trans. Wirel. Commun.*, vol. 5, no. 3, pp. 504–508, Mar. 2006.

[4] H. Y. Chen,M. L. Ku, S. J. Jou, and C. C. Huang, "A robust channel estimator for high-mobility STBC-OFDM systems," *IEEE Trans. Circuits Syst. I, Reg. Papers*, vol. 57, no. 4, pp. 925–936, Apr. 2010.

[5] M. Morelli and U. Mengali, "A comparison of pilot-aided channel estimation methods for OFDM systems," *IEEE Trans. Signal Process.*, vol. 49, no. 12, pp. 3065–3073, Dec. 2001.

[6] Santumon.S.D and B.R. Sujatha, "Space-Time Block Coding (STBC) for Wireless Networks," International Journal of Distributed and Parallel Systems (IJDPS) Vol.3, No.4, July 2012.