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Comparison of BER for Different Scheme in STBC-OFDM Receiver

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Abstract— In this paper the Space-Time Block Codes Orthogonal Frequency Division Multiplexing (STBC-OFDM) 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. Comparison of BER for different schemes is performed in this paper.

Keywords- Space-time block code, orthogonal frequency division multiplexing, Alamouti code.

I. INTRODUCTION

OFDM has become more popular during the last decades, because it provides a substantial reduction in equalization complexity as compared to classical modulation techniques. It has taken more than a quarter of a century for this technology to move from the research domain to the industry. 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. This greatly simplifies the design of both the transmitter and receiver, unlike conventional FDM; a separate filter for each sub channel is not required. OFDM is a digital multi carrier modulation scheme, which uses a large number of closely spaced orthogonal sub-carriers.

For the coherent modulation schemes in the OFDM systems, the channel state information (CSI) is required to compensate channel distortion. It is based on OFDMA technique to support multiple access schemes are used to allow many users to share simultaneously a finite amount of spectrum, MIMO systems over multipath fading channels. STBC-OFDM systems with multiple antennas can provide diversity gains to improve transmission efficiency and quality of mobile wireless systems [1], but accurate channel state information (CSI) is required for diversity combining, coherent detection, and decoding. In order to estimate the transmitted symbols the decoder needs to obtain the channel state information and also use a signal combiner.

As opposed to former standards using OFDM modulation, 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.

II. PROPOSED METHODOLOGY

The orthogonal frequency division multiple access (OFDMA) specification of IEEE 802.16e is supports the multi-antenna technology. In downlink (DL) transmission, the subcarrier allocation of partial usage of subchannels (PUSC) is supported in this system [2]. The quadrature phase shift keying (QPSK) and 16 quadrature amplitude modulation (QAM) are supported for data subcarriers and the binary phase shift keying (BPSK) is supported for pilot subcarriers and preamble symbols. Each frame contains one preamble symbol and 40 OFDM data symbols. The cyclic prefix (CP) length is 128 sampling periods which is same as 1/8 of the useful symbol time. The STBC-OFDM system with two transmit antennas and one receive antenna is shown in Figure 1. In the transmitter, Alamouti's STBC encoding method [1] is used to encode two transmitted symbols. These symbol first pass through the constellation mapper and then pass through serial-to-parallel(S/P) to form two transmitted symbols during a time slot which is equivalent to two OFDM symbol times. These two transmitted symbols are encoded by Alamouti's STBC scheme [1], transformed by N-point inverse fast Fourier transform (IFFT) unit is used in each arm to transform the frequency domain OFDM symbols into time domain. The CP with time duration is then inserted as a guard interval to prevent inter-symbol interference (ISI). Finally, a complete OFDM symbol is transmitted in air.

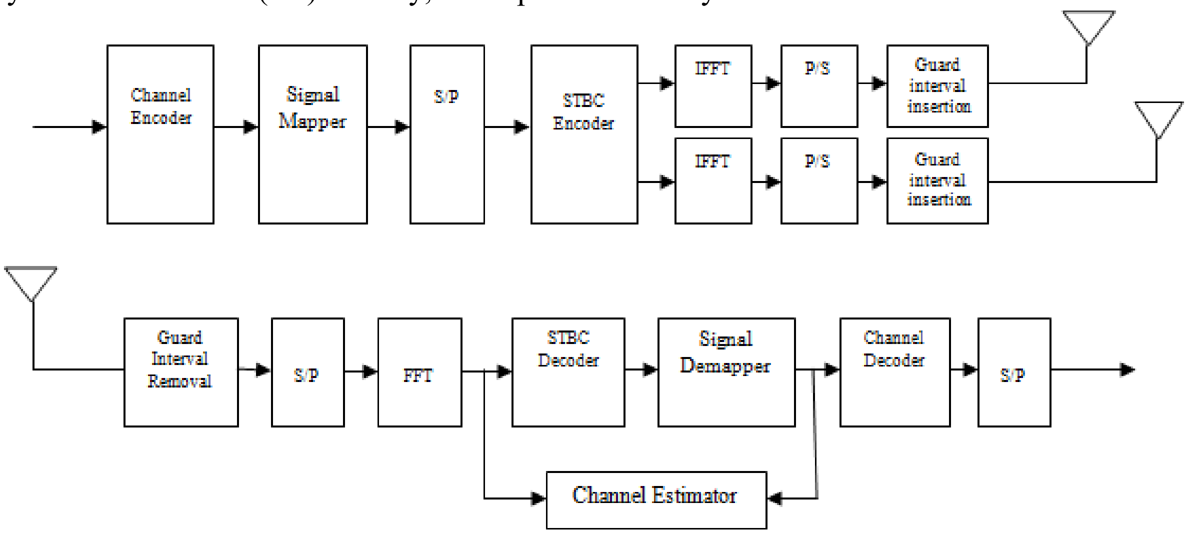

Figure 1. Proposed STBC-OFDM system with two transmits antennas and one receive antenna.

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] [2]. 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

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

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

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.
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 [2]. 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 [2]. Furthermore, when the number of pilots is sufficient, the two schemes have comparable performances [3]. For this reason, the decision-feedback (DF) DFT-based channel estimation method is adopted to use the decided data as pilots to track channel variations for providing sufficient tracking information. Recently, a DF DFT-based method derived from ML criterion and Newton's method is presented. A refined two-stage channel estimation method [4] is more robust than the classical DF DFT-based method to apply in fast time-varying channels.

2.1 OFDM TRANSMITTER RECEIVER:

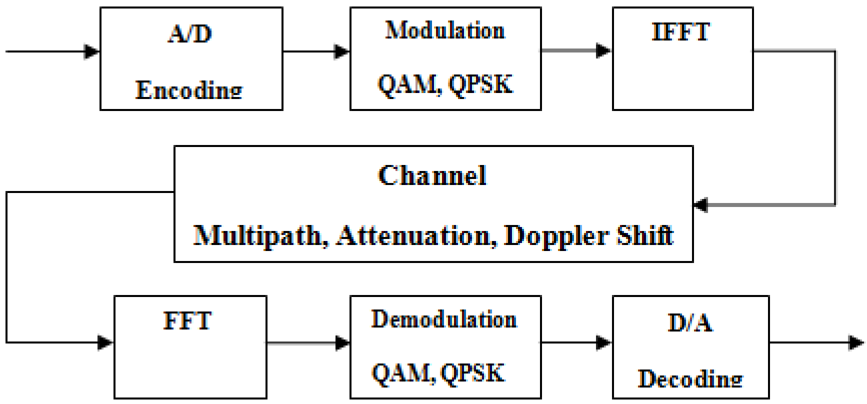

Figure 2. OFDM Block Diagram

Figure 2 shows the block diagram for a basic OFDM transmitter and receiver. Transmitter consists of encoding, modulation and IFFT blocks. Receiver consists of FFT, demodulation and decoding blocks. 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.

2.2 SPACE-TIME BLOCK CODING

Space-time block codes (STBC) are a generalized version of Alamouti scheme [1], 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.
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 [5]. This has made space-time block codes a very popular and most widely used scheme.

2.3 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 [5]. 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:

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

[3]

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 [5].

III. 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. Comparison of BER for SISO, SIMO, MISO, MIMO schemes in STBC-OFDM receiver. The figure 3a shows the plot of bit error rate for SISO scheme, figure 3b shows the plot for SIMO scheme, figure 3c shows the plot for MISO scheme, and figure 3d shows the plot for MIMO scheme. 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.

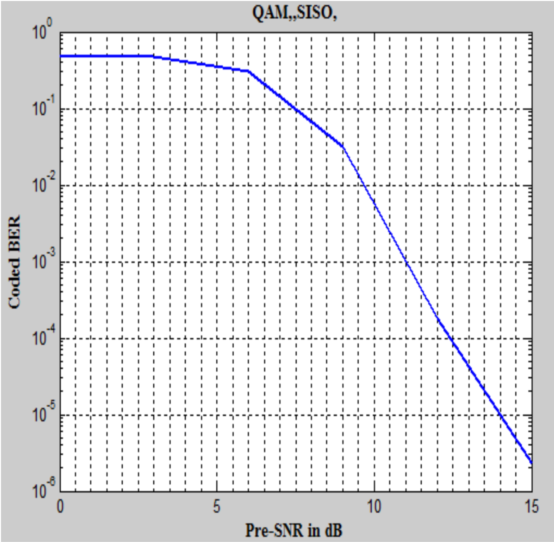

Figure 3a. Bit error rate for SISO system

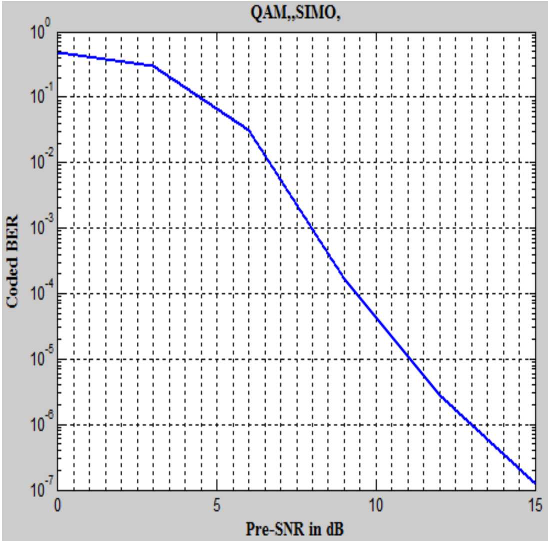

Figure 3b. Bit error rate for SIMO system

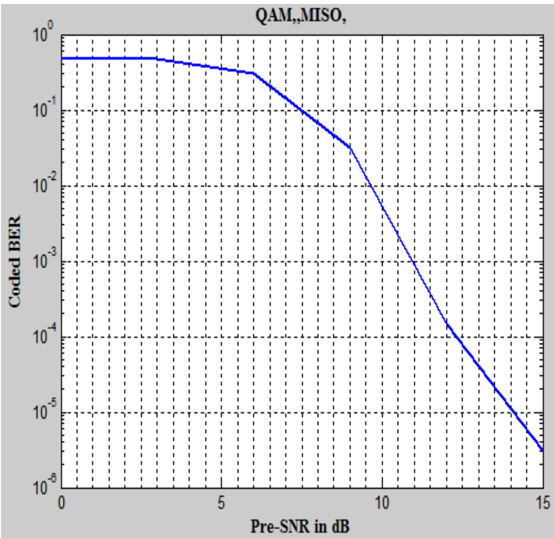

Figure 3c. Bit error rate for MISO system

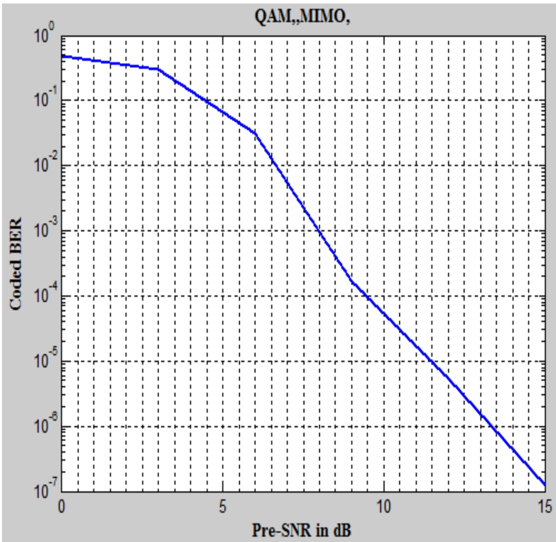

Figure 3d. Bit error rate for MIMO system

IV. 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 a 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 (QPSK and 16-QAM) 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. Comparison of BER for different schemes is performed in this paper.

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