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A Novel Alamouti STBC Technique for MIMO System Using 16-QAM Modulation and Moving Average Filter

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Abstract
The wireless communication is the emerging field of research among communication researchers and they are continuously working towards the reduction if error occurred in the signal during transmission through wireless media. In this paper the wireless system is simulated with the application of Alamouti space time block codes (STBC) with MIMO and MISO configurations to compare the results. The modulation technique used here is 16-QAM which is giving better results than other counterparts and to enhance the performance of the system i.e. to reduce the effect of errors on data we have applied a moving average filter(MAF). The performance of the system is shown with the simulation results with variable data sizes and found that the proposed approach is better for the system.
Keywords- Alamouti STBC, QAM, MIMO and MISO.

I. Introduction

Multiple-input multiple-output (MIMO) system is known to exploit the antenna diversity to develop the performances of wireless communication systems using multiple antenna elements at the transmitter and receiver ends. The main objective of MIMO technology is to improve bit error rate (BER) or the data rate of the communication by applying signal processing techniques at each side of the system. The capacity increases linearly with the number of antennas while using MIMO however it gradually saturates. MIMO system can obtain both multiplexing gain and diversity gain which can help significantly increase the system capacity. The earliest studies considering MIMO channels were carried out by Foschini [2] and Telatar [3]. MIMO can be divided into two main classes, spatial multiplexing (SM) and STC.

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 setting is called as Multiple Input Single Output (MISO) transmit-diversity. A scheme 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 the perfect channel state information is available at the receiver with consideration. On the other hand, when there is high mobility and the channel conditions are fluctuating rapidly it may be difficult to obtain perfect or close to perfect estimates for the channel. To improve this problem another space-time block coding techniques known as DSTBC has been proposed in [4]. In this technique, two serial transmitted symbols are encoded into phase differences and the receiver recovers the transmitted information by comparing the phase of the current symbol with the previously received symbol. Two antennas are used, to send two OFDM symbols and their conjugate functions, in two time slots, which bring a diversity gain without having to compromise on the data rate. Through the open air media, the transmitted symbols will suffer from channel fading and at the receiver, their sum would be received. Here is the schematic diagram of an Alamouti wireless system in 2x2 MIMO mode.

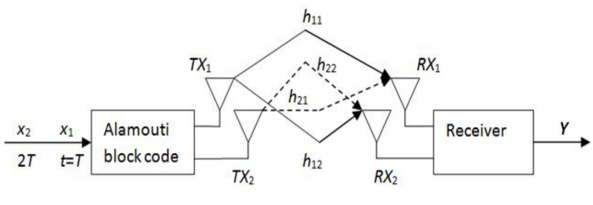

Fig. 1.1 A 2x2 MIMO wireless system using the Alamouti block code

Space-Time Block Codes

Space-time block codes (STBC) are a generalized version of Alamouti scheme. These codes have the same key features. That is, they 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 in both the transmitter and receiver sides. The data are constructed as a matrix which has its rows equal to the number of the transmit antennas and its columns equal to the number of the time slots required to transmit the data. At the receiver side, when signals are received, they are first combined and then sent to the maximum likelihood detector where the decision rules are applied.

Space-time block code was designed to achieve the maximum diversity order for the given number of transmit and receive antennas subject to the constraint of having a simple decoding algorithm. Additionally, space-time block coding provides full diversity advantage but is not optimized for coding gain. In the following, different implementations of space-time block codes are explained in details. This includes the encoding, decoding and system performance for the two and four transmit antennas and two and four receive antennas for both real and complex signal constellations.

II. System Model

Alamouti block code. It is a complex space-time diversity technique that can be used in 2x1 MISO mode or in a 2x2 MIMO mode. The Alamouti block code technique is the only complex block code that has a data rate of *1* while achieving maximum diversity gain. This performance has been achieved using the following space-time block code:

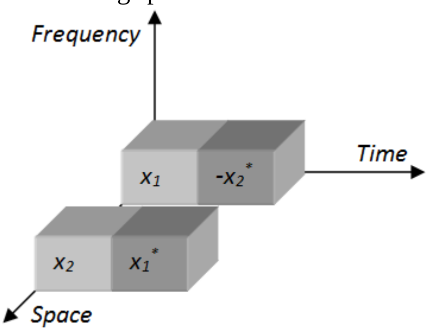

Fig. 1.2 Alamouti space-time diversity technique

Alamouti system is one of the first space times coding schemes developed for the MIMO systems which take advantage out of the added diversity of the space direction. Therefore we do not need extra bandwidth or much time. We can use this diversity to get a better bit error rate (BER). At the transmitter side, a block of two symbols is taken from the source data and sent to the modulator. Afterwards, the Alamouti space-time encoder takes the two modulated symbols, in this case and creates an encoding matrix where the symbol and are planned to be transmitted over two transmit antennas in two consecutive transmit time slots.

The Alamouti encoding function matrix is as follows:

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

A block diagram of the Alamouti ST encoder is shown in Figure 1.3.

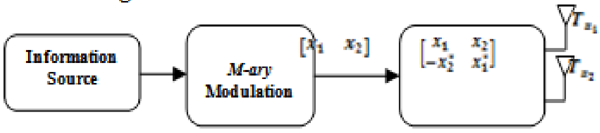

Fig. 1.3 Alamouti Space-Time Encoder.

The Alamouti STBC scheme which has 2 transmit and Nr receive antennas can deliver a diversity order of 2 Nr [6]. Also, since for space time codes the rate is defined as R=k/p (where k is the number of modulated symbols the encoder takes as input and p is the number of transmit antennas) for the Alamouti STBC the rate equals 1.

Alamouti STBC with multi (two) Receiver Antennas

Alamouti scheme can also be used for multiple antennas at the receiver to achieve receive diversity. STBC scheme with two transmit and two receive antennas. Two receive antennas as explained in [7] would increase the diversity gain in comparison to systems with one receive antenna.\

The received signals r_1, r_2, r_3 *and* r_4 from two receive antennas, can be written as:

$$r_1 = h_1 x_1 + h_2 x_2 + n_1$$
$$r_2 = -h_2 x_2^* + h_2 x_1^* + n_2$$
$$r_3 = h_3 x_1 + h_4 x_2 + n_3$$
$$r_4 = -h_3 x_2^* + h_4 x_1^* + n_4$$

Two combined signals that are sent to the maximum likelihood detector, the combiner in Figure 4.4 generates the following outputs

$$\hat{x}_1 = h_1^* r_1 + h_2 r_2^* + h_3^* r_3 + h_4 r_4^*$$
$$\hat{x}_2 = h_2^* r_1 - h_1 r_2^* + h_4^* r_3 - h_3 r_4^*$$

As before the maximum likelihood decoding rule can be written as

$$\hat{x}_1 = \arg\min_{(\hat{x}_1, \hat{x}_2 \in S)} (|h_1|^2 + |h_2|^2 + |h_3|^2 + |h_4|^2 - 1) |\hat{x}_1|^2 + d^2(\hat{x}_1, \hat{x}_1)$$
$$\hat{x}_2 = \arg\min_{(\hat{x}_1, \hat{x}_2 \in S)} (|h_1|^2 + |h_2|^2 + |h_3|^2 + |h_4|^2 - 1) |\hat{x}_1|^2 + d^2(\hat{x}_2, \hat{x}_2)$$

III. Proposed Methodology

The noise is the only disturbing element which affected the transited signal as the case of Rayleigh fading, the MMSE-SISO detector cannot be use, and since the error probability is constant with the SNR.

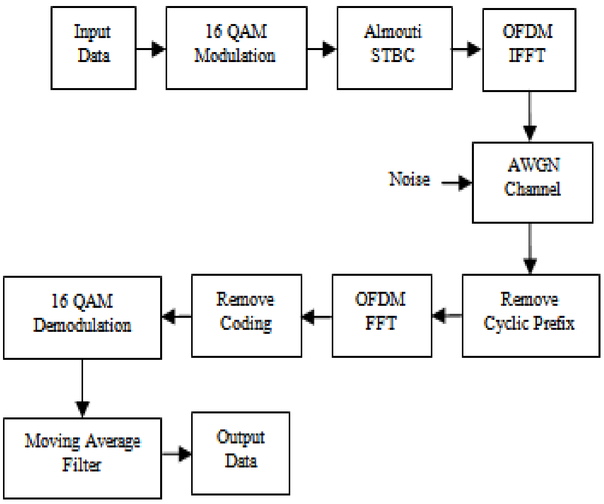

Fig. 3.1 Shows Block Diagram of Proposed Methodology

In the case of MMSE-MIMO systems the bit error rate is decreasing more rapidly with the SNR than in the case of SISO system The MMSE-MIMO detector partially recovers the transmitted data, since the error probability is slowly decreasing with the SNR even after there is a need of improvement in existing system. In our Proposed Methodology we have proposed a novel filtration technique for reducing the Bit Error Rate (BER) on the present system scenario here we proposed the implementation of Moving Average Filter. The simulation would be performed in Matlab environment, and the results would be predicted for achieving a reliable error probability. The scope of filtering technique is to investigate the effect of MIMO technique on the performances achieves by the MMSE detector and reduce the error probability. The BER is used to evaluate and compare the system performances in various situations. In the final result, we expect much better system performance with respect to the level of performance achieved in Existing System.

The given flow chart describes the complete simulation process under which firstly the initialization of signal processing environment variable has been done after this the generation of data is achieved then 16 QAM Modulator is adopted for modulation purpose then after the Alamouti STBC encoding technique is implemented through AWGN MIMO Channel with the consideration of Noise. In the receivers section received signal is recovered from STBC after this 16 QAM Demodulator is adopted for demodulation purpose then Moving Average Filter is implemented to get optimum relation between BER and Signal to Noise Ratio.

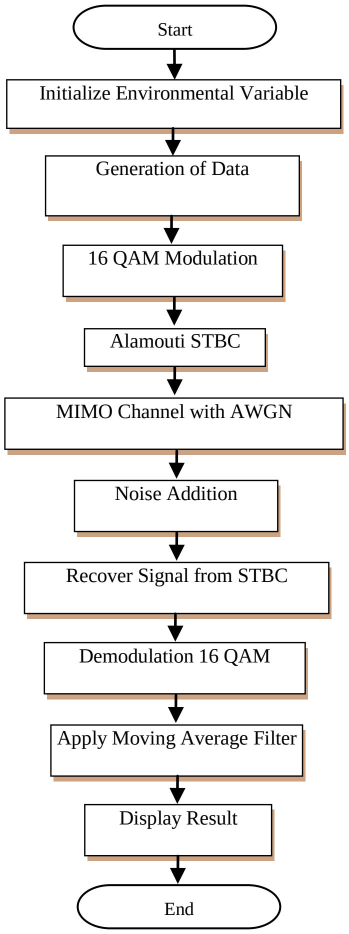

Fig.3.2 Shows the Flow Chart of Complete Simulation Process.

IV. SIMULATION RESULTS

The simulation of the proposed approach is explained in this section. The results of the proposed system calculated as bit error rate as a figure of merit versus signal to noise ratio(SNR). The system is simulated under different data sizes and the variable iteration sizes. Simulation results are shown in below figures.

In Fig. 4.1 the performance of the system in terms of BER is analyzed and it is calculated under multiple input single output system, and the 16-QAM modulation is used with 4 iterations. Whole system is test with 10 bits, 1000 bits and 100000 bits. There is need to enhance the performance of the system and can be done with the decrease in value of bit error rate i.e. reduction in errors, this moving average filter is used and the results with the filter is visible in the figure.

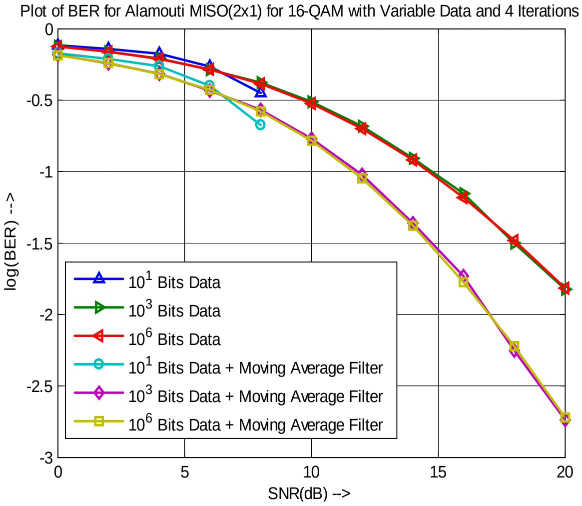

Fig. 4.1 BER performance of proposed system with MISO and moving average filter applying 4 iterations

In Fig. 4.2 the performance of the system in terms of BER is analyzed and it is calculated under multiple input single output system, and the 16-QAM modulation is used with 6 iterations. Whole system is test with 10 bits, 1000 bits and 100000 bits. The results with and without the moving average filter is visible in the figure.

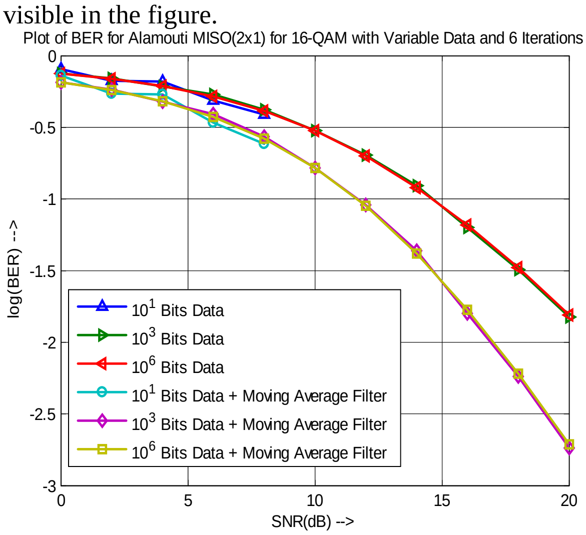

Fig. 4.2 BER performance of proposed system with MISO and moving average filter applying 6 iterations

In Fig. 4.3 the performance of the system in terms of BER is analyzed and it is calculated under multiple input single output system, and the 16-QAM modulation is used with 10 iterations. Whole system is test with 10 bits, 1000 bits and 100000 bits. The results with and without the moving average filter is visible in the figure.

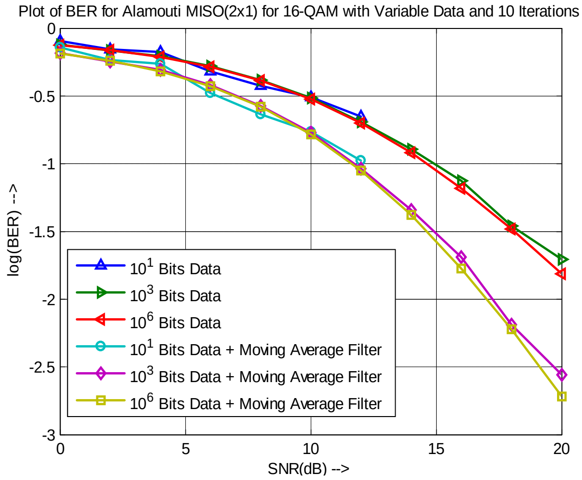

Fig. 4.3 BER performance of proposed system with MISO and moving average filter applying 10 iterations

From the above results it is clear that the system performance is for lower data is better with higher iteration rate and it decreases with increase in data sizes but it can be less considerable because the changes is minor.

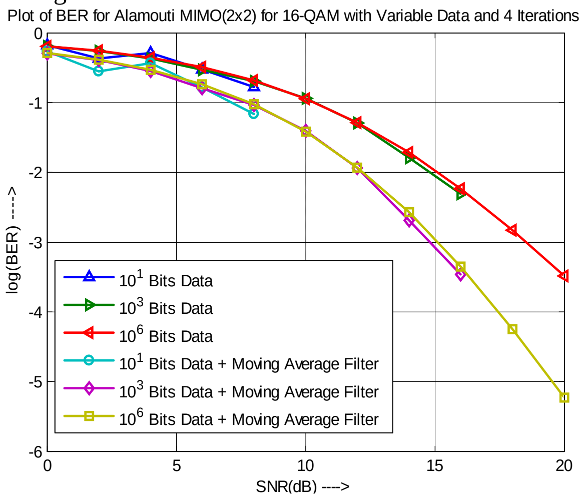

Fig. 4.4 BER performance of proposed system with MIMO and moving average filter applying 4 iterations

After testing system with multiple input and single output(MISO) here now tested with multiple input multiple output (MIMO) system and with the increase in number of receiver antenna the recovery of the signal is more than MISO configuration and the performance of the system quite better.

In Fig. 4.4 the performance of the system in terms of BER is analyzed and it is calculated under multiple input multiple output system, and the 16-QAM modulation is used with 4 iterations. Whole system is test with 10 bits, 1000 bits and 100000 bits. The results with and without the moving average filter is visible in the figure.

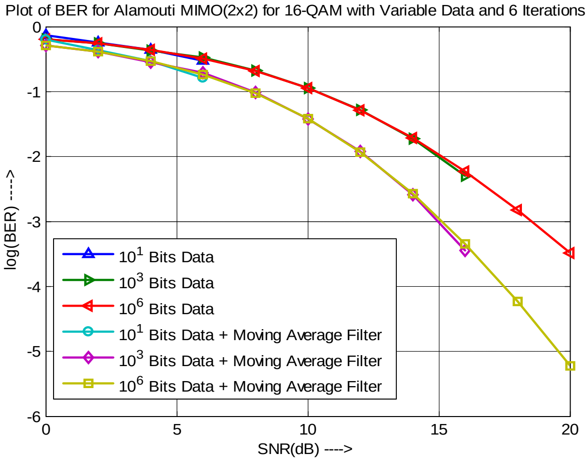

Fig. 4.5 BER performance of proposed system with MIMO and moving average filter applying 6 iterations

In Fig. 4.5 the performance of the system in terms of BER is analyzed and it is calculated under multiple input multiple output system, and the 16-QAM modulation is used with 6 iterations. Whole system is test with 10 bits, 1000 bits and 100000 bits. The results with and without the moving average filter is visible in the figure.

In Fig. 4.6 the performance of the system in terms of BER is analyzed and it is calculated under multiple input multiple output system, and the 16-QAM modulation is used with 10 iterations. Whole system is test with 10 bits, 1000 bits and 100000 bits. The results with and without the moving average filter is visible in the figure.

From the above results for MIMO it is clear that the system performance is for lower data is better with higher iteration rate and it decreases with increase in data sizes but it can be less considerable because the changes is minor, and the system outperform with MIMO as compared to MISO configuration and far better with moving average filter.

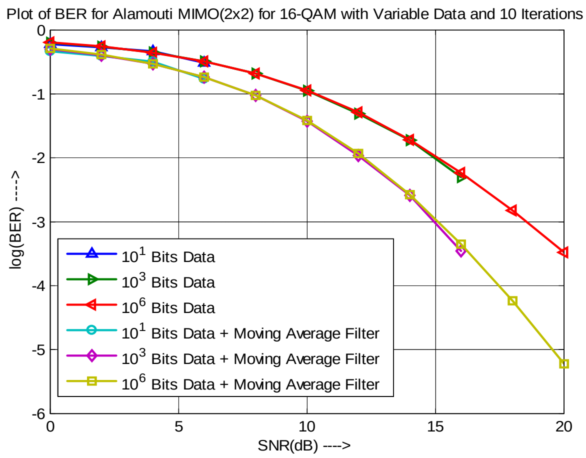

Fig. 4.6 BER performance of proposed system with MIMO and moving average filter applying 10 iterations

V. CONCLUSION AND FUTURE SCOPE

Simulation if system is better with multiple input and multiple output as cleared from the results explained in the previous section. The system with 16-QAM is tested and the with the application of moving average filter enhanced far better because of reduction in error occurred during transmission. System changes its characteristics with the variable data size but not rapid change in performance is visible. So the proposed methodology is good for the better performance of the system compared to previous methods.

In future the system and its performance will be improved by the use of some efficient filtering technique as well as complex modulation scheme added advantage with this.

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