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Performance comparison Bit Error Rate and capacity analysis of Raleigh & Rician Fading Wireless communication System

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Abstract

Cognitive radio (CR) is an advanced technology in order to identify the number of unused channels in the wireless spectrum. This will also shares the spectrum between primary user (PU) and secondary user (SU) in efficient way. The secondary user can coexist with primary user to form the cognitive radio network (CRN). While allocating the spectrum between the users the fading problem may occur. Here we examined the techniques of maximizing ergodic capacity in different fading channel like Rayleigh fading and Rician fading techniques. In order to minimize the transmission error and by using optimum power allocation for calculation of Ergodic system capacity and outage system capacity in Multiple Input and Multiple Output (MIMO). This examination incorporates the Bit Error Rate (BER) execution of Space Time Block Codes (STBC) with Alamouti code for the remote channels like Rayleigh and Rician with QPSK modulation plan. Lagrangian multiplier algorithm and water filling algorithm is used to calculate the power allocation schemes with numerical value and its is observed that water filling algorithm produces better then Lagrangian multiplier algorithm. After analyzing the channel capacity the bit error rate of the channel is calculated.

Keywords*: Cognitive radio, AWGN, Alamouti code, Ergodic capacity and outage capacity*

I. Introduction

The Cognitive Radio (CR) technology was originally investigated by Mitola.J in the year 1999[1]. This technique was developed due to reusing of the frequency spectrum in more efficient way. Generally the cognitive radio network has inbuilt ability to identify the unused spectrum bands. So that harmful interference among licensed primary user and secondary user is avoided. This is known as dynamic spectrum management process. Multiple Input Multiple Output (MIMO) techniques has several antennas in both transmitter and receiver side. This technique helps to transfer more data at same time in wireless communication systems. The MIMO technique is capable enough to choose the distinguish efficient path for each antenna to allow multiple signal transmission. By using MIMO technique the higher data rate can be achieved and the spectral efficiency can be increased. In the fading channels it is difficult to determine the channel capacity [2]. Space Time trellis code helps to increase the performance of multiple input and multiple output channels. To overcome this problem Space Time Block Code (STBC) [3] process is used as an encoding scheme in this paper. This process helps to calculate the channel capacity in simple manner. The bit error rate in wireless channel can be calculated with the help of multicarrier modulation schemes like Quadrature Phase Shift Keying (QPSK). The channel capacity is computed by combining STBC and DQPSK modulation scheme. While the signal is propagated between the transmitter and receiver fading may occur. Multipath fading defines as the contortion that a transporter adjusted telecom signal encounters over certain spread media. Multipath propagation is the outcomes in

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radio signals arriving at the getting receiving wire by at least two ways. The drawback of this multipath fading is increase in error and decrease in the throughput. So that radio frequency link gets damaged. The error gets decreased by introducing some of the fading techniques [4],[5]. In this paper we used Rayleigh, AWGN and Rician fading techniques. The force portion for blurring highlight point subjective MIMO channel with channel state classification is the main focus of the paper. The Maximizing the ergodic capacity is much complicated process and leads to inefficient design for the lossy transmission of source information over wireless networks[6][7].
The simplest code for encoding in STBC is Alamouti code [8]. This code was invented by Siavash Alamouti to achieve the full diversity gain. This code is used to design with many transmitter antenna and one receiver antenna. The main advantage of this code is that the high gain is achieved without lose of any data and also the error rate performance is good. The bit error rate of fading channels is calculated using Alamouti space time block code. Then for decoding process additive white Gaussian noise is performed [9].

The remaining sections are ordered as follows. The system model of cognitive radio MIMO networks is described in section II. Then algorithm used in this paper was explained in section III. The simulation results and discussion is depicted in Section IV and finally the conclusion is explained in section V.
The notations used in this paper are described in Table 1.

Notations	Descriptions
$\|.\|$	Determinant
$(.)^T$	Transpose of matrix
$(.)^*$	Complex conjugate of matrix
I	Identity matrix
$E(.)$	Statistical expectation
$T_r(.)$	Trace of matrix

II. System Model

Let us consider the cognitive radio network shares the spectrum between a secondary transceiver pair and primary network. The primary user radio network consists of M number of transmitter and N number of receiver. Let us assume the primary receiver has R_p number of receive antenna and the primary transmitter has T_p number of transmit antenna. Secondary receiver has R_s number of receive antenna at receiver side and T_s number of transmit antenna at transmitter side. Fig.1 shows the transreceive block diagram of a Cognitive radio system with STBC coding model for this paper.

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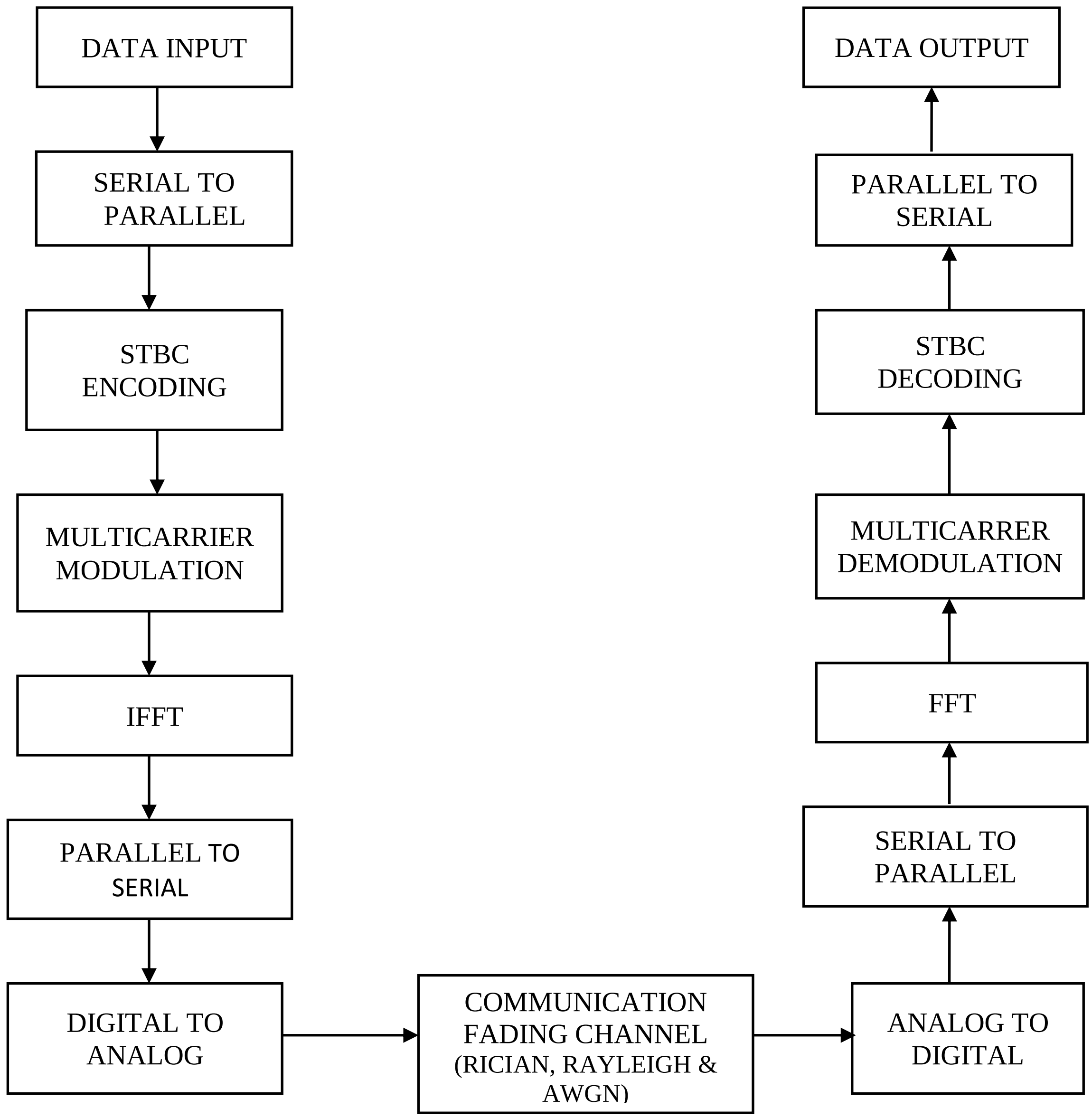

Fig.1 Block diagram

The signals are transmitted in the similar bandwidth between the primary user and secondary user and the signal received at secondary receiver is uttered as:

$Y_s = LG_s + \sum_i TiGp, i + N_o$ ——————————————————————————(1)

In the above equation the channel matrix from secondary transmitter to secondary receiver is denoted as L and the channel matrix from i^{th} primary transmitter to secondary receiver. The signal vector at secondary transmitter is given by G_s and the signal vector at i^{th} primary transmitter is given byGp, i. T_i Transmitted signal of i^{th} primary transmitter, Normalized adaptive white Gaussian noise is denoted as N_o. The capacity of secondary user connection is expressed as

$C_s = \log_2|I + R^{-1}LQL^*|$ ——————————————————————(2)

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Let Secondary transmitter covariance matrix is represented by Q and R represents the covariance matrix along with interfered noise at secondary receiver . The capacity maximization problem at secondary user is

$maximize\ \log_2|I + R^{-1}LQL^*|$

$subject\ to\ T_r(Q) < P_T$

Where P_T is total transmitted power.

Till $T_r(Q)$ Secondary users capacity is maximum and convex but the capacity is non convex for precoding matrix values, so it is hard to solve [13]. This can be solved by maximizing the precoding matrix, STBC code to get nearly optimal power solution.

III. Proposed Algorithm

The Proposed optimum power allocation for MIMO system is used to improve ergodic system capacity and outage capacity. Lagrangian multiplier algorithm [10] and water filling algorithm [11],[12] is used to calculate the power allocation schemes with a few numerical values. In this section we are discussing about the algorithm proposed to decrease the bit error rate.

A. Lagrangian multiplier algorithm

Ergodic capacity in a supreme limit is given by

$$\mathrm{E}(\log_2|I + R^{-1}LQL^*|) \leq E(\log_2|I + E(R^{-1})L\Lambda L^*|) \qquad -------------- (3)$$

Here $E(R^{-1})$ is a crosswise matrix.

Ergodic capacity in a lowest infimum is given by

$$\mathrm{E}(\log_2|I + R^{-1}LQL^*|) \geq E(\log_2|I + E(R^{-1})L\Lambda L^*|) \qquad -------------- (4)$$

The values in diagonal matrix are identical. The elements in channel matrix are identically distributed. The power problem occurred in spectrum reusing is reduced by Lagrangian multiplier algorithm with following steps.

The Lagrangian twin problem can be solved by introducing the loop. The step length of the loop is S_1 and S. The optimal point is connected inside the small range by using Lagrangian algorithm. The power allocation problem is solved by structure of Lagrangian multiplier algorithm. The Lagrangian algorithm structure is formed if the gradient value is recognized.

Algorithm

Initialization:

$$K > 0\ , V_n > 0, P_o > 0$$

Repeat

1. Revise **F**
2. Repeat

$$P_o = \left(P_o + t_1^* \left(\Psi_i\ (\alpha_i, \Lambda) - K - \sum_i V_n\ \|G_n f_i\| \right) \right)$$

Awaiting every P_o connects

3. Revise

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$$K = \left(K + t_2^* \left(P_T - \sum_{i=1}^{M_S} P_o \right) \right)$$

$$V_n = \left(V_n + t_2^* \left(\|G_n f_i\|^2 P_o \right) \right)$$

Awaiting K, V_n connects

With the help of $\Psi_i\ (\alpha_i, \Lambda)$ this value and gradient value the optimum power P_o is calculated.

B. Water Filling Algorithm

Optimum power can be calculated by Lagrangian multiplier algorithm is somewhat difficult. To make the process as simple we are using water filling algorithm. When compared with Lagrangian multiplier algorithm the water filling algorithm is simple and easy to compute the optimum power in a channel.

By using the statistical expression of I and R^{-1} the optimum power is calculated in water filling algorithm. The optimum maximization problem can be expressed by the following equation.

$$maximize \sum_i \|G_n f_i\|\ P_o < P_T$$

$P_o > 0$ for all i

Water filling algorithm can be explained as steps .

1. Obtain the inverse channel gain.
2. Because of inverse channel gain the structure of this algorithm is not standardized.
3. Then calculate the inverse power gain by adding the total power and inversing the channel gain.
4. Initialize the average water level with the help of average power allocated.
5. Final step is calculating the sub channel power value. Then check the value of power and if it is negative then stop the operation.

Algorithm

Initialization

Assign Number of channels

Let Number of transmitting (N_t) channels and Number of Receiving channels (N_r)

$T=N_t=N_r=2$

$N_1=1$, $N_2=7$

Total power transmission, P_t = 10dB, 20dB, 30dB

Power allocation

$P_i=P_t$ / T; i=1,2

Capacity C = B* $\log_2 (1 + P_i)$ bits/ sec.

Water filling capacity

$C_{wf} = \frac{1}{2} * \sum_{i=1}^{T} \log_2(1 + P_i/N_i)$ bits/sec.

The Lagrangian problem handles the twin trouble whereas the water filling algorithm connects the optimum power value within the small range.

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IV. Simulation results and Discussion

The dynamic cognitive radio network shares the spectrum between a secondary transceiver pair and primary network. The number of transmitting antenna and receiving antenna in secondary user side will be assumed as $R_s = T_s = 2$. Then the average capacity value is calculated by using the water filling algorithm and Lagrangian multiplier algorithm. STBC code is used for simulation process. Based on STBC and modulation method the bit error rate is determined. The average energy is obtained by

$$E_{avg} = \frac{1}{T}\sum_{i=1}^{T}\left(a_i^2 + b_i^2\right) \quad (5)$$

Symbol error rate is calculated by

$$P_e \cong 2\left(1 - \frac{1}{T}\right) erfc\left(\sqrt{\frac{2E_{avg}}{2(T-1)N_o}}\right) \quad (6)$$

The Bit error rate of QPSK is calculated by

$$P_e = erfc\sqrt{\frac{E}{2N_o}} \quad (7)$$

Fig.2 Illustrate the 8000 samples of randomly generated input data for Rayleigh fading channel.

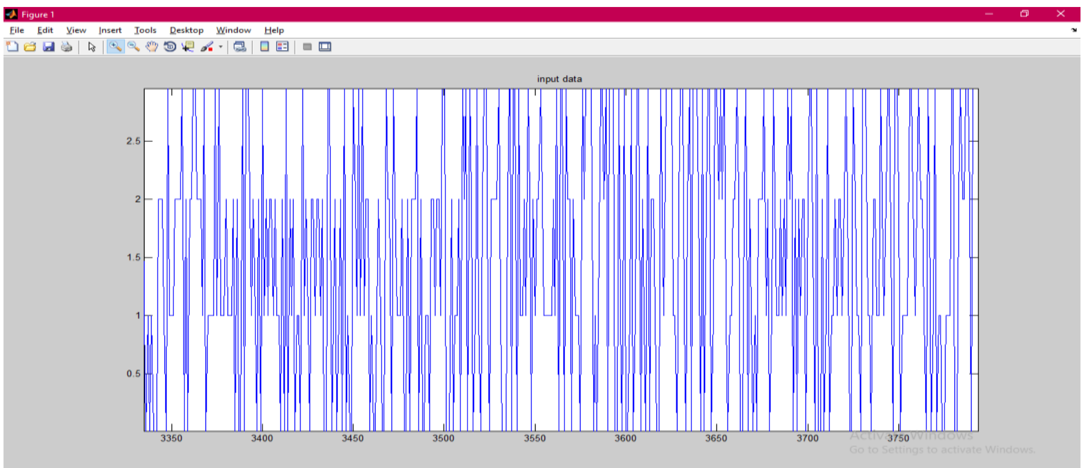

Fig.3 Illustrates the Calculated BER for a SNR varies from 0 dB to 40dB for a Rayleigh fading.

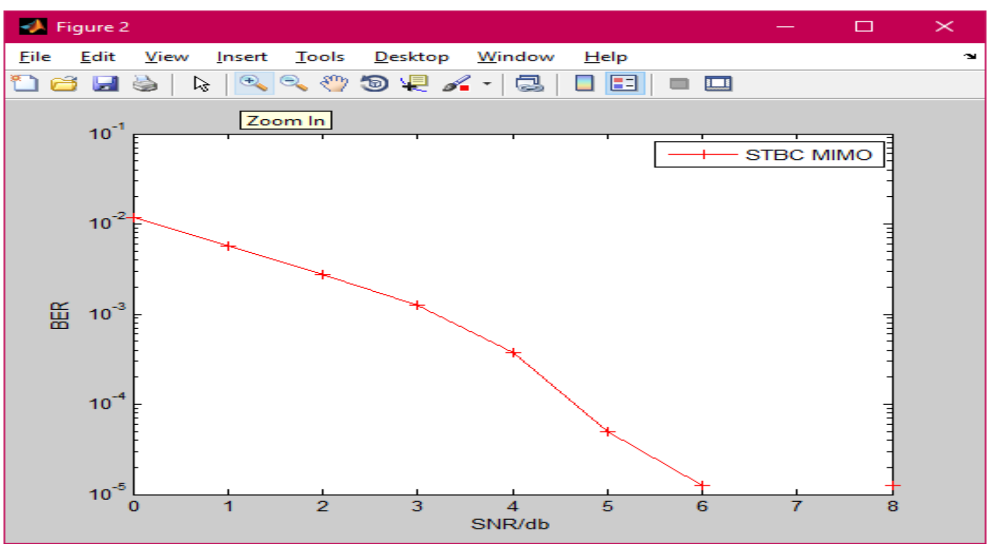

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Fig.3 is the graph plot by Signal to Noise Ratio with respect to the Bit Error Rate for Rayleigh channel using STBC encoder. The bit error rate at specific SNR is calculated by using Alamouti code without lose of any data rate and uses Quadrature Phase Shift Keying (QPSK) modulation.

Fig.4 Illustrates the input data of Rician fading channel which we given to the system. It consists of random data of 80000 samples.

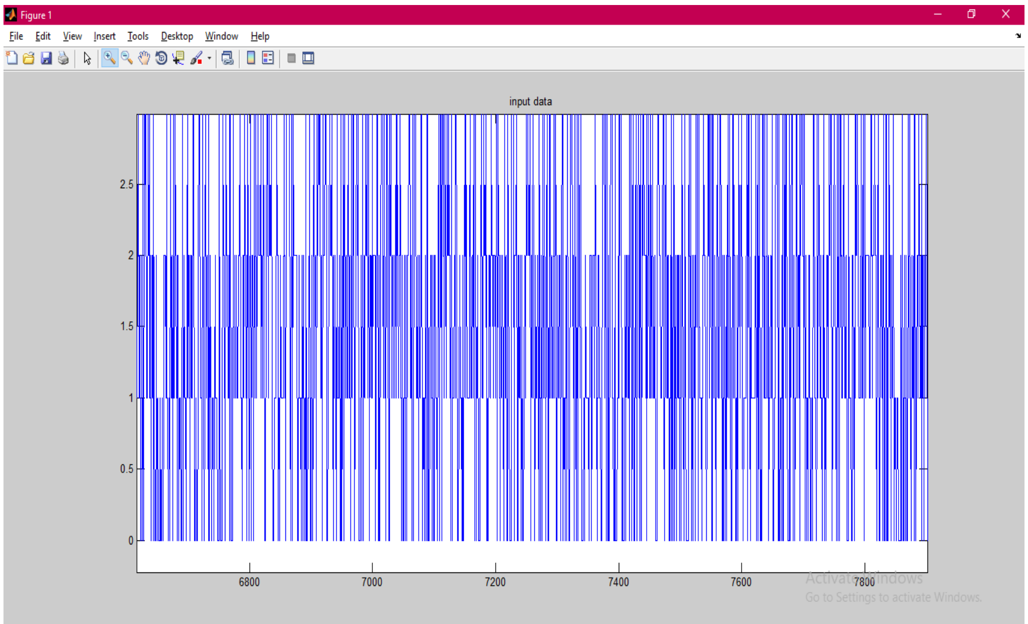

Fig.5 shows the graph plotted with SNR with respect to BER for the Rician fading channel.

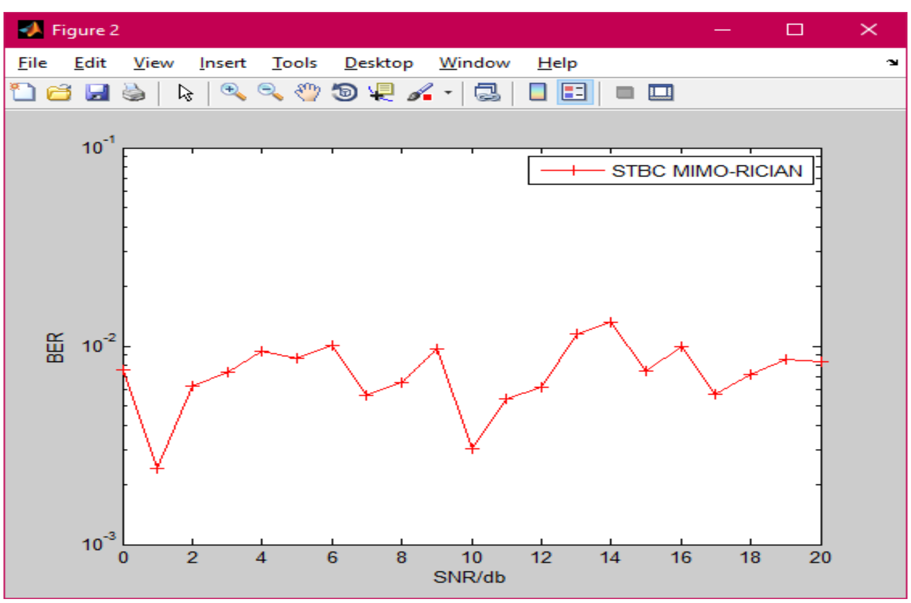

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Fig.5 is the graph plot by Signal to Noise Ratio with respect to the Bit Error Rate for Rician using STBC encoder. The bit error rate at specific SNR is calculated by using Alamouti code without lose of any data rate and uses Quadrature Phase Shift Keying (QPSK) modulation.

Fig 6 shows Rician fading channel system capacity estimation by using water filling algorithm and Lagrangian multiplier algorithms.

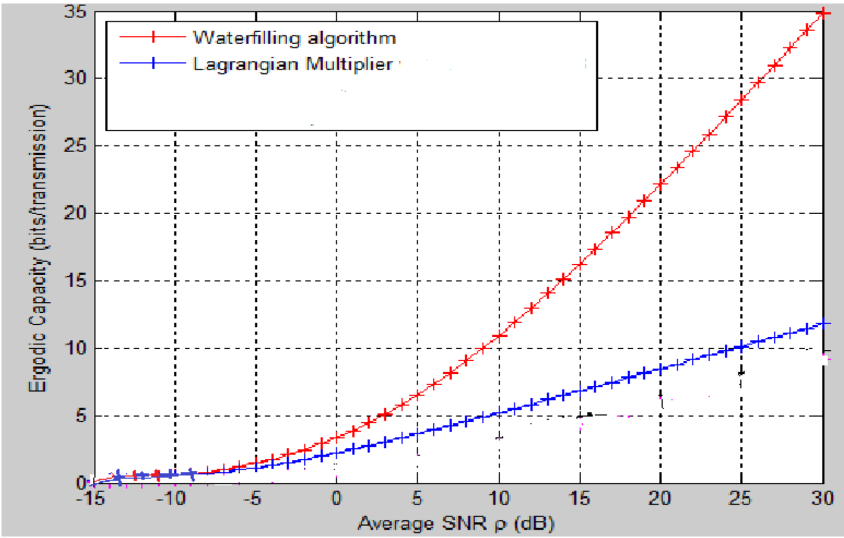
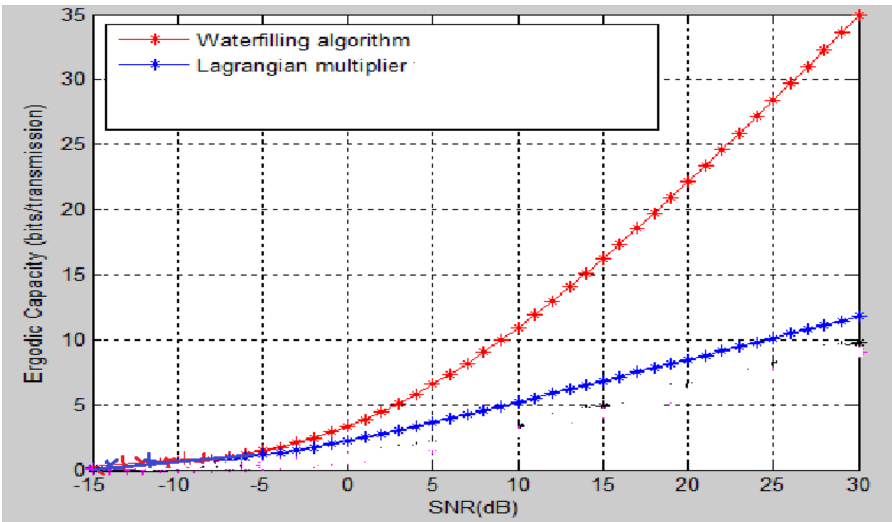


Fig 7 shows Rayleigh fading channel system capacity estimation by using water filling algorithm and Lagrangian multiplier algorithms.



From the figure 4 and Figure 5 it is clear that Bit error rate calculated with Alamouti code with QPSK modulation for SNR value of 0 to 40dB, the Rayleigh channel error value is minimum compared to

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Rician channel. In Rician channel BER value does not remain minimum and also it oscillates between the upper and lower limits.

From the figure 6 and Figure 7 it is clear that for both the Rayleigh and Rician channel, the Water filling algorithm is performance is better and reaches utmost higher for MIMO with equal number of Antennas at both transmitters and receivers.

V. Conclusion

In wireless communication MIMO technique uses multiple antennas to transfer the data. In this paper we used STBC technique to transfer the data through antennas. We consider the primary communication and secondary communication takes place simultaneously. Space Time Block Code with QPSK modulation method is used to calculate the symbol error rate bestows excellent performance in channel system capacity for both wireless channels. Ergodic capacity improves by using the Water filling algorithm and Lagrangian multiplier algorithm. Based on the performance the water filling algorithm improves the outage capacity and ergodic capacity. Then bit error rate (BER) is calculated with respect to signal to noise ratio by Alamouti code. This will achieve the full diversity gain and error performance is better. The error rate in the Rayleigh fading channels can be minimized by Alamouti code compared to Rician channel. The optimum power will be attained in simplest way. Since the tradeoff and throughput performance is better it can be implemented in real time process.

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