

PERFORMANCE COMPARISON OF (2TX1R) AND (2TX2R) MIMO CDMA SYSTEM USING SPACE TIME BLOCK CODE (STBC)

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ABSTRACT

The demand for wireless communication systems with high data rates and high capacity has dramatically increased. CDMA (Code Division Multiple access) plays an important role in modern wireless communication systems. MIMO refers to links with multiple antennas at the transmitter and receiver side. For next generation cellular system CDMA & MIMO is very necessary technology and performance of depend upon the spreading strategy. We proposed MIMO-CDMA system with STBC (Space-Time Block Code) matrices for spreading and outcome permutation spreading method. Simulation results shows that gain improvement with STBC approach as compared to other existing techniques. MIMO is a technique to increase data rate significantly with multiple antennas at both the transmitter and receiver. MIMO takes the advantage of random fading and multipath delay spread. MIMO systems will need to function reliably in interference limited environment in order to be effective. CDMA systems are designed to operate in an interference free environment and for this reason it is used in modern cellular systems. The combination of MIMO and CDMA can further improve the system transmission rate over the traditional CDMA system. Multiuser MIMO CDMA systems are considered where each user has multiple transmit antennas, different transmit antennas of the same user use the same spreading code. In this paper space time block coding with 2 transmit antenna and two receive antenna can be consider Using MATLAB as a simulation tool. A comparison statement is develop between 2x1 and 2x2 transmitter and receiver combination and obtain performance of the system with one, two, transmitting antenna over the rayleigh channel.

Keywords: Discrete Cosine Transform, Fast Fourier Transform, JPEG

I. INTRODUCTION

Wireless communication is the transfer of information over a distance without the use of electrical conductors or "wires". We can optimize various types of mobile, fixed and two-way radios, cellular system and wireless system which demand the wireless communication services grown tremendously. For the next generation system like 3rd generation network has been much slower than already existing system and our goal to introduce much higher network against exiting network. Researchers are already investigating 4th generation systems and this system will transmit at much higher rates than the actual 2G systems, and even 3G systems, in an ever crowded frequency spectrum. Signals in wireless communication environments are impaired by fading and multipath delay spread and due to fading the overall performance of the system become degrade. Hence, several

avenues are available to mitigate these impairments and fulfill the increasing demands. The demand for wireless communication systems with high data rates and high capacity has dramatically increased. CDMA (Code Division Multiple access) plays an important role in modern wireless communication systems. MIMO refers to links with multiple antennas at the transmitter and receiver side. In CDMA systems, the narrowband message signal is multiplied by a very large bandwidth signal is a Spread sequence as space time block code Space-time block coding is a technique used in wireless communications to transmit multiple copies of a data stream across a number of antennas and to exploit the various received versions of the data to improve the reliability of data-transfer. In this work MIMO-CDMA(with two transmitter and two receiver) system is designed with STBC (Space-Time Block Code) matrices for spreading [2]. The proposed technique outperforms the design permutation spreading method and also the conventional method. Simulation results shows that gain improvement with STBC approach as compared to other existing techniques. This work deals with orthogonal space-time block coding schemes and a realistic channel model was used. In MIMO-CDMA to improve the bit error rate performance parity bit selected spreading sequences are introduced initially [2], in this linear block coding technique is used. In that Parity bits are used to select the spreading sequence from a set of orthogonal spreading sequences. Information can be added with spreading code and at receiver, the spreading code help out to determine the filter output and Message bits are recover from the specific match filter. Error in specific information can be correct by assuming that parity bits are correct. In this paper, Spreading permutations scheme is introduce to improve the BER performance for MIMO CDMA System. As earlier techniques, this technique improves the BER but additional complexity introduces [3]. Recently, there are a large number of researches for multiple inputs multiple outputs (MIMO) in CDMA transmission.

II. STBC AND EXPERIMENT STEP

MIMO systems can be defined as arbitrary wireless communication system, consider a link in which the transmitting ends as well as the receiving end is equipped with multiple antenna elements as shown in Figure 1. The idea behind MIMO is that the signals on the transmit (TX) antennas at one end and the receive (RX) antennas at the other end are “combined” in such a way that the quality (bit-error rate or BER) or the data rate (bits/sec) of the communication for each MIMO user will be improved. Such an advantage can be used to increase both the network’s quality of service and the operator’s revenues significantly [4][5][6][7].

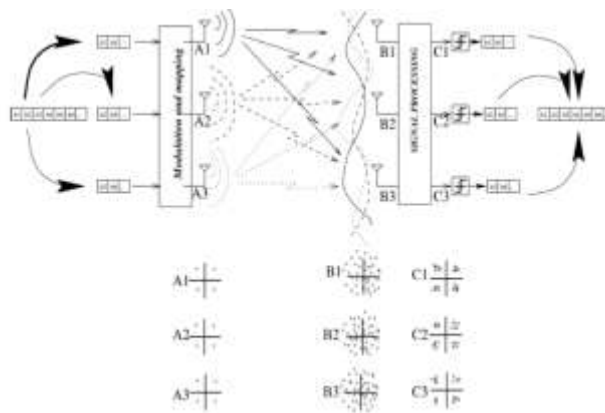


Figure 1: Multiple Input Multiple Output system.

Core idea in MIMO [1] systems are space-time signal processing in which time (the natural dimension of digital communication data) is complemented with the spatial dimension inherent in the use of multiple spatially distributed antennas. As such MIMO systems can be viewed as an extension of the so-called smart antennas, a popular technology using antenna arrays for improving wireless transmission dating back several decades. It is important to note that each antenna element on a MIMO system operates on the same frequency and therefore does not require extra bandwidth. Also, for fair comparison, the total power through all antenna elements is less than or equal to that of a single antenna system. i.e.,

$$\sum_{k=1}^N p_k \leq P$$

Where N is the total number of antenna elements, p_k is the power allocated through the kth antenna element, and P is the power if the system had a single antenna element. Effectively, the equation ensures that a MIMO system consumes no extra power due to its multiple antenna elements [5][6][8][11]. At the transmitter side, a block of two symbols is taken from the source data and sent to the modulator. After that, Alamouti space-time encoder takes the two modulated symbols, in this case called s_1 and s_2 creates encoding matrix S where the symbols s_1 and s_2 are mapped to two transmit antennas in two transmit time slots.

The encoding matrix is given by:

$$S = \begin{bmatrix} s_1 & s_2 \\ -s_2^* & s_1^* \end{bmatrix}$$

The fading coefficients denoted by $h_1(t)$ and $h_2(t)$ are assumed constant across the two consecutive symbol transmission periods and they can be defined as:

$$\begin{aligned} h_1(t) &= h_1(t+T) = h_1 = |h_1|e^{j\theta_1} \\ h_2(t) &= h_2(t+T) = h_2 = |h_2|e^{j\theta_2} \end{aligned}$$

The receiver receives r_1 and r_2 denoting the two received signals over the two consecutive symbol periods for time t and $t+T$. The received signals can be expressed by:

$$\begin{bmatrix} r_1 \\ r_2 \end{bmatrix} = \begin{bmatrix} s_1 & s_2 \\ -s_2^* & s_1^* \end{bmatrix} \begin{bmatrix} h_1 \\ h_2 \end{bmatrix} + \begin{bmatrix} n_1 \\ n_2 \end{bmatrix} = \begin{bmatrix} h_1 s_1 + h_2 s_2 + n_1 \\ -h_1 s_2^* + h_2 s_1^* + n_2 \end{bmatrix}$$

The maximum likelihood (ML) decoder chooses a pair of signals (s_1, s_2) from the signal constellation to minimize the distance metric over all possible values of s_1 and s_2 .

$$\begin{aligned} &d^2(r_1, h_1 \hat{s}_1 + h_2 \hat{s}_2) + d^2(r_2, -h_1 \hat{s}_2^* + h_2 \hat{s}_1^*) \\ &= |r_1 - h_1 \hat{s}_1 - h_2 \hat{s}_2|^2 + |r_2 + h_1 \hat{s}_2^* - h_2 \hat{s}_1^*|^2 \end{aligned}$$

For phase-shift keying (PSK) signals, the decision rule can be expressed by:

$$\begin{aligned} &d^2(\hat{s}_1, s_i) \leq d^2(\hat{s}_1, s_k) \quad \forall i \neq k \\ &d^2(\hat{s}_2, s_i) \leq d^2(\hat{s}_2, s_k) \quad \forall i \neq k \end{aligned}$$

$$\begin{bmatrix} \tilde{s}_1 \\ \tilde{s}_2 \end{bmatrix} = \begin{bmatrix} h_1^* & h_2 \\ h_2^* & -h_1 \end{bmatrix} \begin{bmatrix} r_1 \\ r_2 \end{bmatrix} = \begin{bmatrix} h_1^* r_1 + h_2 r_2^* \\ h_2^* r_1 - h_1 r_2^* \end{bmatrix}$$

The combiner shown in Figure 2 builds the following two combined signals that are sent to the maximum likelihood detector.

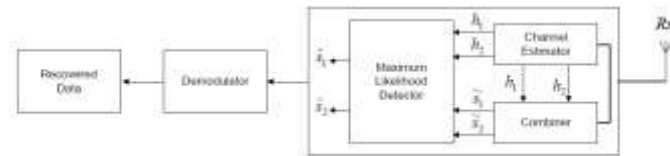


Figure 2: Alamouti space-time decoder

The principle of space time block coding with 2 transmit antenna and one receive antenna with STBC. With two receive antenna's the system can be modeled as shown in the figure below

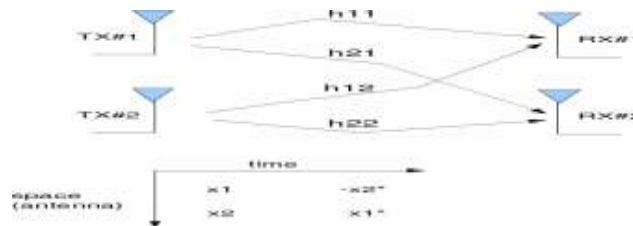


Figure: 3 Transmit 2 Receive with STBC

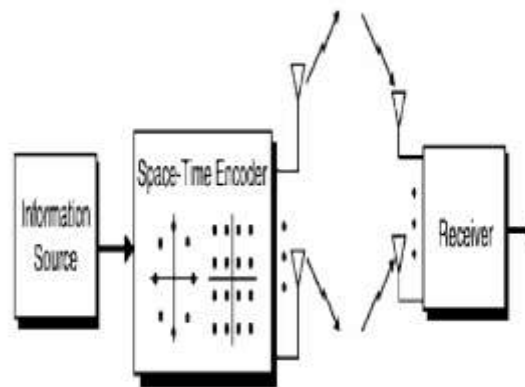


Figure 4: Overall Block diagram

In conventional MIMO-CDMA, each user use a different spreading code for each transmitting antenna. In conventional MIMO-CDMA system the spreading waveforms are fixed.

$$W_{mi} = C_{mi}(t - nT) \text{----- (1)}$$

Where W_{mi} is the spreading waveform for i th data stream of user m and C_{mi} is the orthogonal spreading sequence. Each antenna uses one spreading waveform, for $N_t = 4$ antennas system 4 spreading waveforms are required per user. At the receiver side, the received data is given bank of matched filters. Orthogonal space-time block codes (O-STBC) achieve high transmit diversity and have a low complexity decoding algorithm at the receiver using any number of transmit and receive antennas [10][11].

III. MIMO-CDMA DESIGN

The receiver performs a time correlation operation to detect only the specific desired codeword. All other code words appear as noise due to decorrelation [12]. For detection of the message signal, the receiver needs to know the codeword used by the transmitter. Each user operates independently with no knowledge of the other users. CDMA is achieved by modulating the data signal by Space Time Block Code [13].



Fig4:-Block Diagram for Transmission



Figure 5:-Block Diagram for Reception

Improving the capacity of code-division-multiple access (CDMA) systems through advanced signal processing has been an area of intensive research for many years, with limited success. Multiantenna technologies called multiple-input multiple outputs (MIMO) are an obvious candidate to increase, particularly, downlink capacity. Nearly all research on MIMO-CDMA, however, has focused on increasing the throughput achieved per user, rather than increasing the number of supportable users, which is still the most important design goal in QoS-constrained voice systems[16]. The objective is to evaluate the MIMO OFDM performance and to reach its optimal data transmission. This was accomplished by selecting an OFDM standard and evaluating its performance under several user-channel profiles[17][21][22].

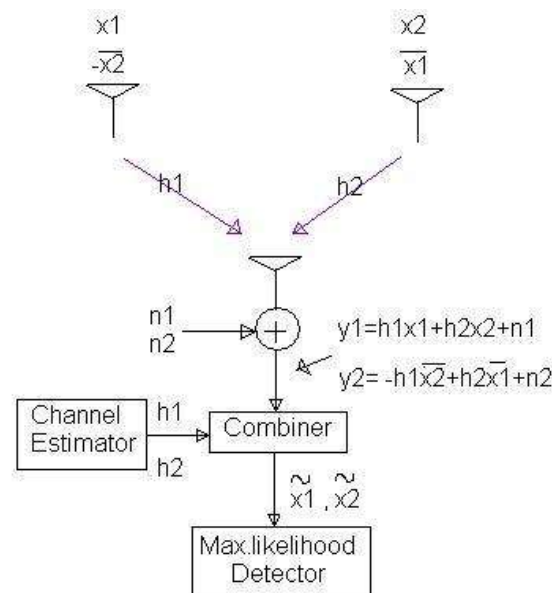


Figure 6: MIMO STBC STBC 2TX1R

In this case study we can consider two scenarios to perform the performance the comparison in 2Tx1R and 2Tx2R transmitter –receiver combination and goal of the research to introduce MIMO Technology in CDMA using state space block coding. A novel transmission scheme is developed to effectively combine permutation

spreading technique with MIMO-OFDM to obtain improved bit error rate performance in the presence of frequency selective fading channels with low system complexity [18]. Unlike conventional MIMO-OFDMA, where users are separated in different frequency bands (sub channels), and each user is coded separately using STBC or SFBC, the proposed new scheme enables multi access by joint code design across multiple antennas, subcarriers, and users. Such system will benefit from the combined space and frequency domain freedom as well as multiuser diversity [19]. Hence, better spectrum efficiency is achieved while improving bit error rate performance with respect to signal-to-interference ratio.

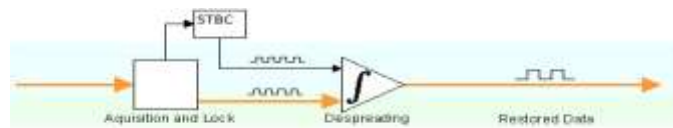


Fig5: space-time decoder/Encoder

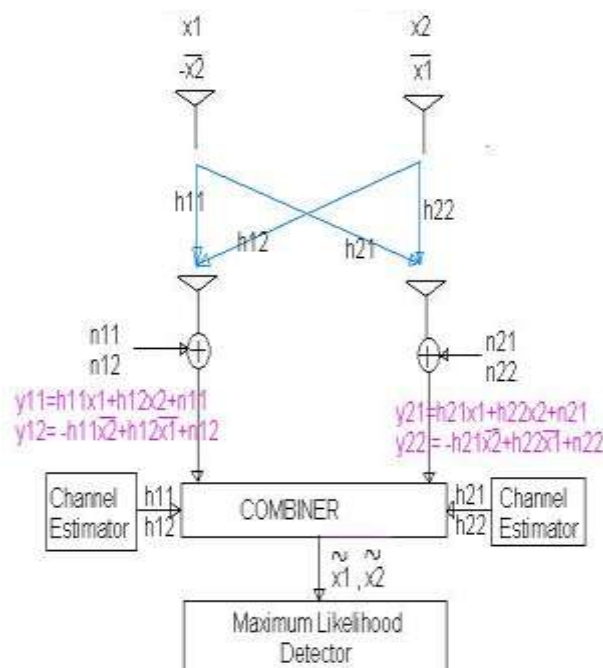


Figure 7 MIMO STBC 2Tx2R

Frequency selectivity challenge due to the large bandwidth in the next generation wireless communications is a major problem; as a result subcarriers in OFDM may experience high frequency dependent attenuations on transmission over such frequency selective fading channels. In a non-line-of sight multipath transmission environment, the symbols carried by the subcarriers are consequently erased by the channel attenuations and cannot be accurately recovered at the receiver, which results a poor system performance. It thus becomes fundamental to exploit the spatial diversity made possible by MIMO system especially when the channel and array structures are such that the transfer functions between different transmit and receive antenna pairs are sufficiently uncorrelated. ST coded MIMO-OFDM cannot neither achieve multipath diversity nor high rate, on the other hand, SF-coded MIMO- OFDM is considered the best candidate for future wireless communication. By mapping the symbols on other sub-channels, it can exploit the multipath diversity. However, the system complexity is a major obstacle and the decoding complexity problem has to be tackled. In addition to that, most

of the existing ST/SF codes are designed for single user systems only, for multiple access channels (MAC), the single-user ST/SF codes are always applied to each user independently, which results a reduced transmission rate.

This technique was originally proposed for CDMA in and recently adapted for MIMO-CDMA in the presence of frequency selective fading channel. A novel approach is developed here to effectively combine and permutation block spreading techniques with MIMO-OFDM to obtain improved bit error performance in the existence of frequency selective fading channel and greatly lower system complexity. In MIMO-OFDMA, users are separated in different frequency bands (sub-channels), and each user is coded separately using STBC or SFBC, leading to data rate reduction for each user when the number of users is increasing. The proposed new scheme enables multi access through the use of orthogonal spreading codes, where multiple data symbols share common subcarriers while their signals remain separable at the receiver. With suitable selections of spreading codes, the frequency diversity created by multipath propagation in the communications channel is exploited to improve the bit error rate (BER) over standard OFDM. Based on the matched filters decision, the transmitted data is estimated. Space-time block coding is a technique used to improve the performance of a wireless transmission system, where the receiver is provided with multiple signals carrying the same information. The concept behind space-time block coding is to transmit multiple copies of the same data through multiple antennas in order to improve the reliability of the data-transfer through the noisy channel. This is shown in

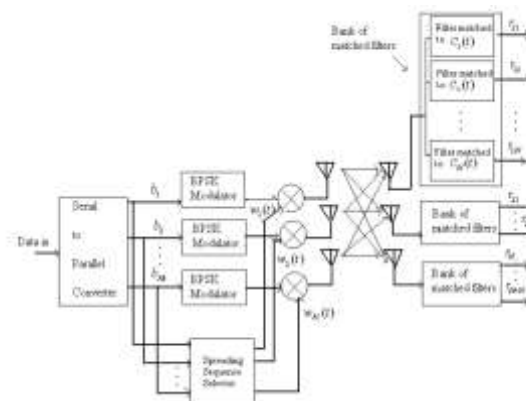


Figure 8: Overall Block diagram for MIMO-CDMA with STBC

The Matlab performs the following operation

1. Generate random binary sequence of +1's and -1's.
2. Group them into pair of two symbols
3. Code it as per the Space Time code, multiply the symbols with the channel and then add white Gaussian noise.
4. Equalize the received symbols
5. Perform hard decision decoding and count the bit errors

Repeat for multiple values of E_b/N_0 and plot the simulation and theoretical results.

IV. MODEL FOR SIMULATION AND SCENARIO

An antenna is a device used for transmitting and/or receiving electromagnetic waves which are operated in radio frequencies (RF), a range of 10 kHz to 300 GHz. The size and shape of antennas are determined from the frequency of the signal they are designed to receive. An antenna must be tuned to the same frequency band that the radio system to which it is connected operates in, otherwise reception and/or transmission will fail. Therefore, antennas couple electromagnetic energy from the space to other mediums. In the recent years, due to the wireless cellular evolution many antenna technologies were proposed which provide more quality, capacity, and coverage. These types of antenna systems are the sectorized antenna systems, diversity antenna systems and many others. However, antennas are operated in a noisy environment where many hostile effects should be surpassed or minimized in order for the communication.

Multipath interference is a phenomenon where two or more waves are transmitted at the same time from a base station and travel through different paths towards the receiving end whereas, before the reception they interfere with each other causing a phase shift.

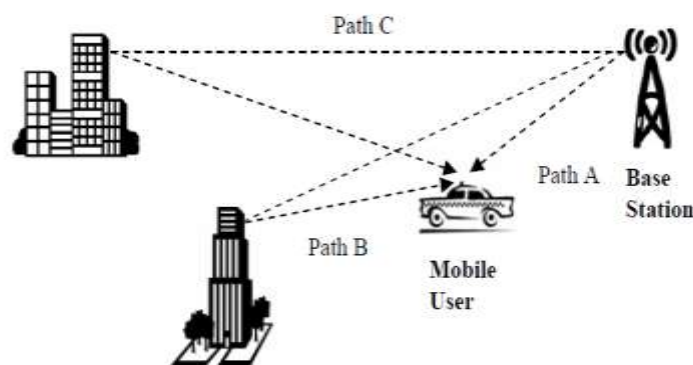


Figure 9: Fading Model

Wireless communication industry has recently turned to a strategy called Multiple-Input Multiple-Output (MIMO). MIMO is the single most important wireless technology as of today. MIMO is a technology evolution where both ends of the wireless link are equipped with antenna arrays; this can improve the quality (bit-error rate) and the data rate (bits per sec). Therefore, a superior quality of service (QoS) can be achieved, which revenues the wireless provider. Many space-time block codes for different numbers of transmit/receive antennas have been developed in order to achieve maximum diversity. MIMO takes advantage of multipath interference effect to increase the user and data capacity; it converts it into a positive feature by using the multiple transmitters and/or receivers to increase throughput and reliability. Usually, multiplexing would cause interference, but MIMO uses the additional pathways to transmit more information and then combines the signal at the receiving end; thus provides robustness against multipath fading. MIMO systems can be designed with the receiver knowing the channel state (coherent case) or not (non-coherent case).

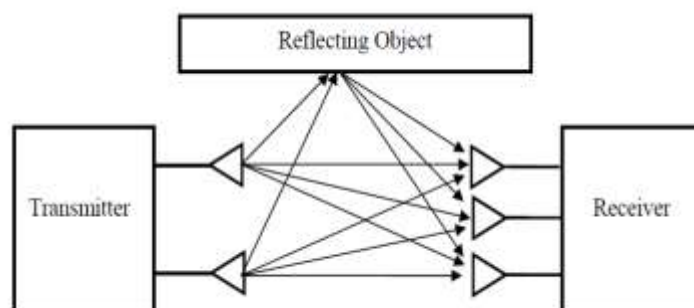


Fig9: Multipath Fading Tansmission And Reception

An efficient way to improve data rate and transmission reliability over wireless links is through the use of MIMO systems each pair of transmit-receive antennas has a single scalar channel coefficient. In this paper, our main focus to calculate the performance of the system for (2:2) transmitter- receiver and (4:4) transmitter-receiver scenario. Performance comparison shows complexity of the system and BER of the system.

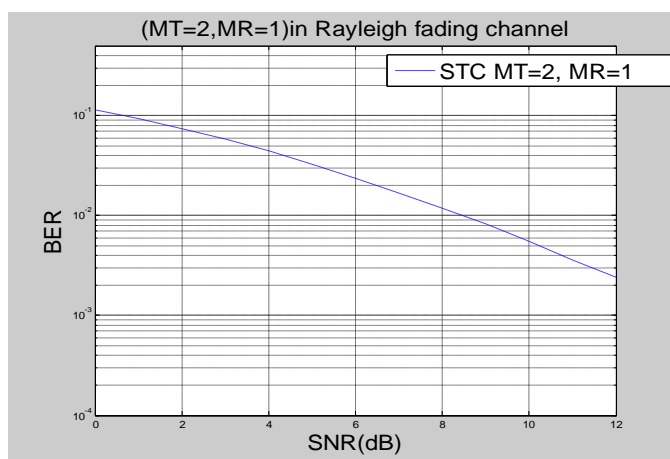


Figure 10: BER vs SNR at MT=2 and MR=1

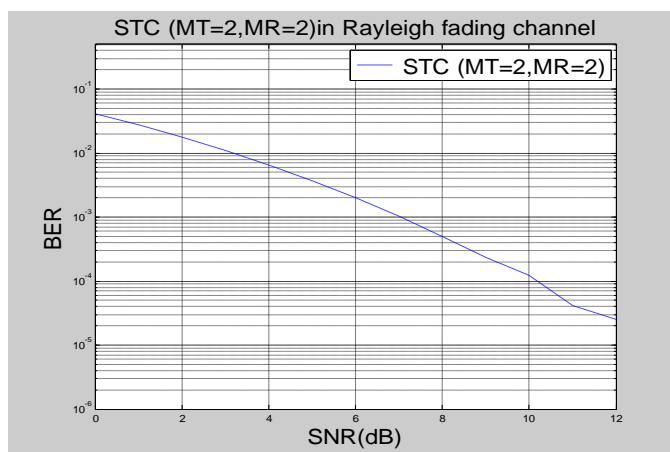


Figure 11: BER vs SNR at MT=2 and MR=2

V. RESULT AND FUTURE SCOPE

We can observe that better results are produced by the system which uses more number of receiver antennas. This is due to the fact that as the number of receiver antennas increases, the diversity of the system will increase.

Higher diversity will give better performance. So while designing the STBC for a particular application, it is needed to select the number of antennas at both ends of the communication link, the modulation and the rate of transmission. By using the proper STBC technology, it is possible to improve the data rate and range of the wireless communication systems

Finally as a future expansion of this paper, it is possible to introduce different modulation schemes to increase the data rates. Also we can increase the number of antennas at both transmitter and receiver without introducing any interference in between the antennas.

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