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Bit Error Rate Performance Analysis with Beamforming Techniques.

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Abstract: *In the wireless communication system, there exists a problem of fading signals, due to which sometimes very weak signal will be received on another side resulting in errors in received bits. Bit error rate (BER) should be improved for getting good quality of a signal. One of the ways to improve BER is Beam Forming technique. In this paper, we have attempted to provide a clear image of improving Bit error rate of 4*4 MIMO system by various beamforming techniques. Firstly improved BER by adding 2 transmit and 4 receive antenna and secondly improve BER by using various beamforming techniques. The results show that variations in bit error rate based on various beamforming techniques using MATLAB codes.*

Keywords: *MIMO, OFDM, BER, STBC, Beam Forming.*

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I. Introduction

"Performance Analysis of MIMO-Mobile WiMAX System using Space-Time Block Codes under Different Channels" Broadband Wireless Access (BWA) has emerged as a promising solution for providing the internet access technology which is used to provide high-speed internet access to the users in the small and medium-sized enterprise sectors as well as in the residential area. Actually, IEEE 802.16e is one of the most promising and attractive candidates among the emerging technologies for broadband wireless access. So that the emergence of the WiMAX protocol has attracted various interests from almost all the fields of wireless communications. Multiple input multiple output systems which are created according to the IEEE 802.16-2005 standard (WiMAX) under different fading channels can be implemented to get the benefits of both the MIMO and WiMAX technologies. In this paper, the MIMO-mobile WiMAX system is simulated for adaptive and constant modulation schemes with ½ and the ¾ code rate of convolutional code to evaluate and analyze bit error rate performance under AWGN, Rayleigh and Rician channels with the help of MATLAB. Simulation results have shown that MIMO-mobile WiMAX system with various modulation schemes is able to achieve better BER performance at different values of Eb/No under different channels. Hence, different Be/No values can be used as a threshold value in designing adaptive modulation systems commercially to achieve acceptable BER performance for MIMO-mobile WiMAX systems presented in [1]

"BER Analysis of MIMO OFDM System for AWGN & Rayleigh Fading Channel" The presence of Guard Period plays a very vital role in improving the BER performance of the MIMO-OFDM system. The performance of the system enhanced to a significant extent on a suitable value of Guard Period along with suitable modulation technique. And also the results show the fact that the QPSK is best-suited modulation technique for MIMO OFDM system in the presence of Guard period while QAM reports no improvement in the BER performance of the system. Also, there is a further possibility of improving the BER performance by developing new technology to compensate for ISI effect, as the Guard period insertion affects system efficiency due to increased overhead. presented in [2]

"BER Analysis of MIMO-OFDM System
Using Various Modulation Schemes" This work presents the performance of MIMO -

OFDM system using various modulations techniques over a Rayleigh fading channel. Finally For the higher orders of PSK schemes more SNR requirement is reported to target an acceptable BER over the simulated channel. After that, QAM requests fewer SNR as compared to PSK to achieve a suitable BER and is approximately the same as that of BPSK. Lower order modulation schemes can be considered, but this is at the disbursement of data throughput. Also, it is essential to balance all the available factors to realize a satisfactory bit error rate. Generally, all the requirements are not achievable and some tradeoffs are necessarily presented in [3]

"BER Performance Analysis of MIMO-WiMAX Wireless Communication System for the Transportation of Multimedia Data" With implementation execution using MATLAB software, we can go for analysis of wireless fading channel environment, as the nature of fading increases to the certain extent and the data rate is also increased to the great extent, one of the ways to get good BER performance of the system is increasing the spatial diversity. We analyzed the working of Almouti STBC under the different modulations and under the different fading channel. From this analysis, we get to know that as modulation index is increased, there is increased in BER that means degraded the performance of a system. With the help of increasing the number transmitter or receiver, we can achieve better performance of the proposed implementation. Finally, with the subjective and objective quality assessment of the data, we can prove that the Implemented system is having improved performance presented in [4]

"Performance Analysis of Mobile WiMAX System using Forward Error Correction and Space-Time Coding Techniques" Mobile WiMAX system using LDPC and Turbo coding for different modulation schemes under Rayleigh channel is simulated. QAM and PSK modulation techniques were used

for analysis. From simulation results, it is concluded that Turbo code gives better BER performance than LDPC codes. MIMO-mobile WiMAX system was also simulated. STBC and STTC techniques were implemented. 2x2 configurations provided better results than 2x1 configuration presented in [5]

In this paper we improved the BER by adding 2 transmit and 4 receive antenna and also improve BER by using various beam forming techniques.

In section (II), define the system model in which we describe the MIMO system, its channel and different diversity modes In section (III), define the description in which the alamouti STBC with two receive antenna are describe with the mathematical model. In section (IV), observe the result by receiver antenna, firstly we shows the result when receiver end has 2 antennas and after that when receiver end has 4 antennas. And also observe the result through various beam forming techniques and shows the simulation using receiver antenna and also shows the simulation using beam forming techniques. In section (V) Conclusion.

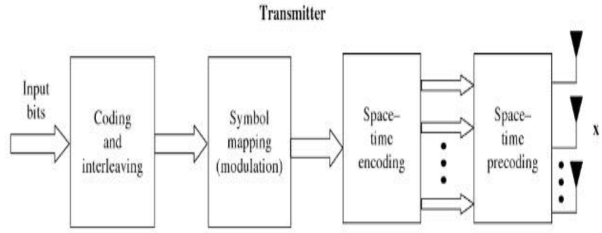
II. System Model

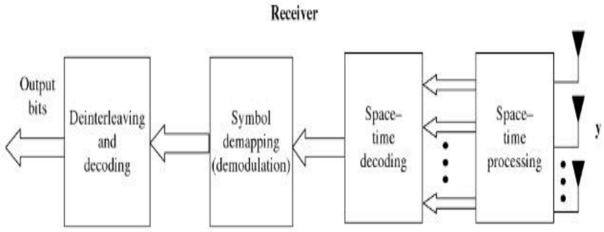
MIMO is effectively a radio antenna technology as it uses multiple antennas at the transmitter and receiver to enable a variety of signal paths to carry the data, by which choosing separate paths for each antenna to enable multiple signal paths to be used. There are many MIMO wireless routers on the market, and as this RF technology is becoming more widespread, more MIMO routers and other items of wireless MIMO equipment will be seen.

In this process sometime the channel may be affected by fading and this will impact the signal to noise ratio. And this will impact the error rate, assuming digital data is being transmitted. Hence the principle of diversity is to provide the receiver with multiple versions of the same signal. If these signal can be made to be affected in different ways by the signal path, the probability that they will all be affected at the same time is considerably reduced. So in this way diversity helps to stabilize a link and improves performance, reducing error rate.

There are different diversity modes which are as follows

- **Time diversity:** By using time diversity, a message may be transmitted at different times, e.g. using different timeslots and channel coding.
- **Frequency diversity:** This diversity uses different frequencies. These frequencies may be in the form of using different channels, or technologies such as spread spectrum / OFDM.
- **Space diversity:** This diversity used in the broadest sense of the definition is used as the basis for MIMO. Space diversity uses antennas located in different positions to take advantage of the different radio paths that exist in a typical terrestrial environment.



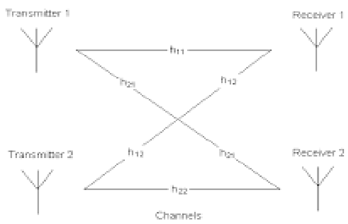


MIMO SYSTEM

III. Description

Alamouti STBC with two receive antenna

With the two receive antenna's the system can be modeled as shown in the figure below.



The received signal in the first time slot is,

$$\begin{bmatrix} y_1^1 \\ y_2^1 \end{bmatrix} = \begin{bmatrix} h_{11} & h_{12} \\ h_{21} & h_{22} \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} n_1^1 \\ n_2^1 \end{bmatrix} \text{.......(1)}$$

Assuming that the channel remains constant for the second time slot, the received signal is in the second time slot is,

$$\begin{bmatrix} y_1^2 \\ y_2^2 \end{bmatrix} = \begin{bmatrix} h_{11} & h_{12} \\ h_{21} & h_{22} \end{bmatrix} \begin{bmatrix} -x_2^* \\ x_1^* \end{bmatrix} + \begin{bmatrix} n_1^2 \\ n_2^2 \end{bmatrix} \text{......(2)}$$

Where

$$\begin{bmatrix} y_1^1 \\ y_2^1 \end{bmatrix}$$

This is the received information at time slot 1 on receive antenna 1, 2 respectively

$$\begin{bmatrix} y_1^2 \\ y_2^2 \end{bmatrix}$$

This is the received information at time slot 2 on receive antenna 1, 2 respectively, h_{ij} is the channel from i^{th} receive antenna to j^{th} transmit antenna,

x_1, x_2 are the transmitted symbols,

$$\begin{bmatrix} n_1^1 \\ n_2^1 \end{bmatrix}$$

This is the noise at time slot 1 on receive antenna 1, 2 respectively and

$$\begin{bmatrix} n_1^2 \\ n_2^2 \end{bmatrix}$$

This is the noise at time slot 2 on receive antenna 1, 2 respectively.
Combining the equations at time slot 3and 4,

$$\begin{bmatrix} y_1^1 \\ y_2^1 \\ y_1^{2*} \\ y_2^{2*} \end{bmatrix} = \begin{bmatrix} h_{11} & h_{12} \\ h_{21} & h_{22} \\ h_{12}^* & -h_{11}^* \\ h_{22}^* & -h_{21}^* \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} n_1^1 \\ n_2^1 \\ n_1^{2*} \\ n_2^{2*} \end{bmatrix}$$

Let us define $\boldsymbol{H} = \begin{bmatrix} h_{11} & h_{12} \\ h_{21} & h_{22} \\ h_{12}^* & -h_{11}^* \\ h_{22}^* & -h_{21}^* \end{bmatrix}$

To solve for $\begin{bmatrix} x_1 \\ x_2 \end{bmatrix}$, we know that we need to find the inverse of H.
We know, for a general m x n matrix, the pseudo inverse is defined as,

$$\boldsymbol{H}^+ = (H^H H)^{-1} H^H.$$

The term,

$$(H^H H) = \begin{bmatrix} |h_{11}|^2+|h_{21}|^2+|h_{12}|^2+|h_{22}|^2 & 0 \\ 0 & |h_{11}|^2+|h_{21}|^2+|h_{12}|^2+|h_{22}|^2 \end{bmatrix}$$

Since this matrix is a diagonal matrix, so that the inverse is just the inverse of the diagonal elements, i.e.

$$(H^H H)^{-1} = \begin{bmatrix} \frac{1}{|h_{11}|^2+|h_{21}|^2+|h_{12}|^2+|h_{22}|^2} & 0 \\ 0 & \frac{1}{|h_{11}|^2+|h_{21}|^2+|h_{12}|^2+|h_{22}|^2} \end{bmatrix}$$

The estimate of the transmitted symbol is,

$$\widehat{\begin{bmatrix} x_1 \\ x_2^* \end{bmatrix}} = (H^H H)^{-1} H^H \begin{bmatrix} y_1^1 \\ y_2^1 \\ y_1^{2*} \\ y_2^{2*} \end{bmatrix}$$

Beam forming

Beam forming is a type of RF (radio frequency) management in which an access point uses multiple antennas to send out the same signal. . In another sense, beam forming shapes the RF beam as it traverses the physical space of the enterprise. In this process by sending out multiple signals and analyzing the feedback from clients, the wireless LAN infrastructure can adjust the signals it sends out and determine the best path the signal should take to reach a client device. Beam forming consists of transmitting the same signal with different gain and phase over all source antennas such that the receiver signal is maximized [7]. Beam forming - A transmitter and receiver pair can perform beam forming and direct their main beams at each other, thereby increasing the receiver's received power and consequently the SNR.

A beam former is used to combines the signals received by the different elements of an antenna array to form a single output.

IV. Result and simulation

Result by receiver antenna

In this paper, the BER performance of 4*4 MIMO system is to be improved by adding 2 transmit and 4 receive antenna and also analyze some variations through various beam forming techniques. The table shows the comparison between BER and various beam forming techniques.

This table shows the variation in the BER performance with receiver antenna RX=2 and RX=4.

SNR (db)X	**Result(BER) (RX=2) Y**	**Result (BER) (RX=4) Y**
0	0.0402	0.0061
1	0.0276	0.0030
2	0.0181	0.0013
3	0.0111	5.6000e-04
4	0.0066	2.000e-04
5	0.0037	6.7000e-05
6	0.0020	2.6000e-05
7	0.0011	4.0000e-06
8	5.6000e-04	0
9	2.4300e-04	0
10	1.2200e-04	0
11	4.9000e-05	0
12	3.0000e-05	0
13	1.1000e-05	0
14	5.0000e-06	0
15	1.0000e-06	0
16	0	0
17	1.0000e-06	0
18	0	0
19	0	0
20	0	0
21	0	0
22	0	0
23	0	0
24	0	0
25	0	0
26	0	0
27	0	0
28	0	0
29	0	0
30	0	0

Result by beam forming

This table below shows the variation in the BER performance through various beam forming techniques.

SNR (db)	**Result without beam forming (BER) Y**	**Adaptive**	**Beam a signal with random noise**	**Broadband normal beam**
0	**0.0402**	0.0402	0.0404	0.0405
1	**0.0276**	0.0276	0.0277	0.0275
2	**0.0181**	0.0179	0.0180	0.0179
3	**0.0111**	0.0111	0.0112	0.0113
4	**0.0066**	0.0068	0.0066	0.0065
5	**0.0037**	0.0037	0.0037	0.0036
6	**0.0020**	0.0020	0.0020	0.0020
7	**0.0011**	0.0011	0.0011	0.0011
8	**5.6000e-04**	4.8700e-04	5.1700e-04	4.9200e-04
9	**2.4300e-04**	2.1900e-04	2.7100e-04	2.3000e-04
10	**1.2200e-04**	1.0900e-04	1.0800e-04	1.1600e-04
11	**4.9000e-05**	6.3000e-05	5.0000e-05	3.9000e-05
12	**3.0000e-05**	3.4000e-05	1.0000e-05	2.5000e-05
13	**1.1000e-05**	5.0000e-06	9.0000e-06	6.0000e-06
14	**5.0000e-06**	1.0000e-06	2.0000e-06	5.0000e-06
15	**1.0000e-06**	2.0000e-06	4.0000e-06	2.0000e-06
16	**0**	2.0000e-06	1.0000e-06	0
17	**1.0000e-06**	0	0	0
18	**0**	0	0	0
19	**0**	0	0	0
20	**0**	0	0	0
21	**0**	0	0	0
22	**0**	0	0	0
23	**0**	0	0	0

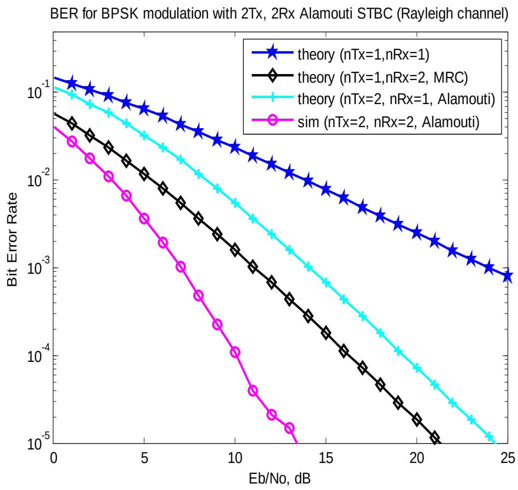
24	**0**	0	0	0
25	**0**	0	0	0
26	**0**	0	0	0
27	**0**	0	0	0
28	**0**	0	0	0
29	**0**	0	0	0
30	**0**	0	0	0

Bartlett beam	**Taylor beam**	**Taylor window**	**Transmit beam with QAM**	**Transmit beam**
0.0403	0.0401	0.0402	0.0404	0.0405
0.0276	0.0274	0.0277	0.0274	0.0276
0.0181	0.0178	0.0178	0.0179	0.0180
0.0111	0.0111	0.0112	0.0111	0.0112
0.0065	0.0066	0.0067	0.0067	0.0067
0.0036	0.0038	0.0038	0.0037	0.0036
0.0020	0.0019	0.0020	0.0022	0.0020
0.0010	0.0011	0.0010	0.0011	0.0010
4.9800e-04	5.1800e-04	4.8600e-04	4.9300e-04	5.0800e-04
2.0800e-04	2.4700e-04	2.3500e-04	2.4600e-04	2.5400e-04
1.0700e-04	1.1800e-04	1.100e-04	1.2300e-04	1.0900e-04
5.2000e-05	5.8000e-05	5.5000e-04	5.2000e-05	5.8000e-05
3.0000e-05	2.2000e-05	2.6000e-05	1.7000e-05	2.6000e-05
6.0000e-06	1.0000e-05	3.0000e-06	9.0000e-06	1.0000e-06
6.0000e-06	9.0000e-06	4.0000e-06	7.0000e-06	4.0000e-06
2.0000e-06	2.0000e-06	2.0000e-06	0	4.0000e-06
0	2.0000e-06	0	0	1.0000e-06
0	0	0	0	0
1.0000e-06	0	1.0000e-06	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0

Simulation using receiver antenna

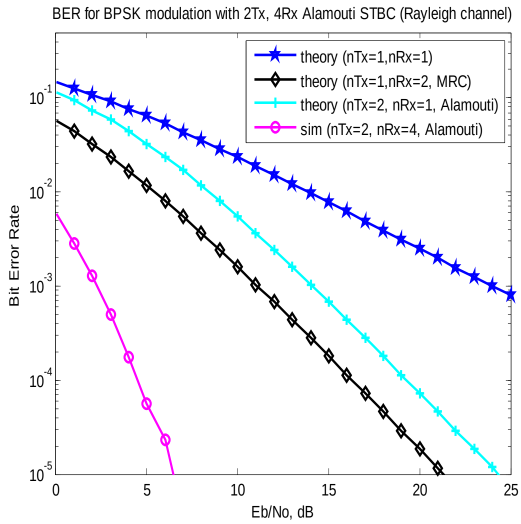
Comparison between Bit error rate for BPSK modulation with 2 Tx and 2 Rx antenna and 2 Tx and 4 Rx antenna

Bit error rate for BPSK modulation with 2 Tx and 2 Rx antenna



This graph shows the bit error rate for BPSK modulation with 2 Tx and 2 Rx antenna.

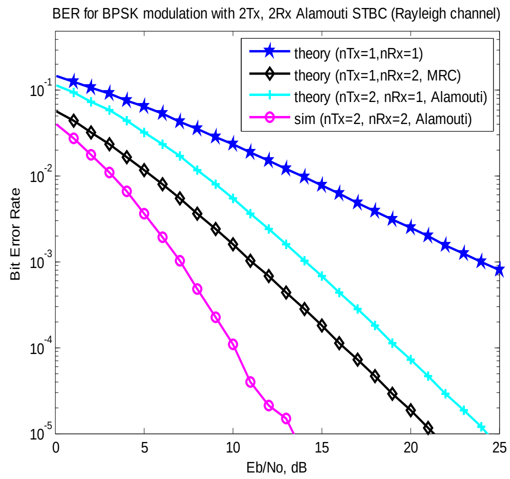
<u>Bit error rate for BPSK modulation with 2 Tx and 4 Rx antenna</u>



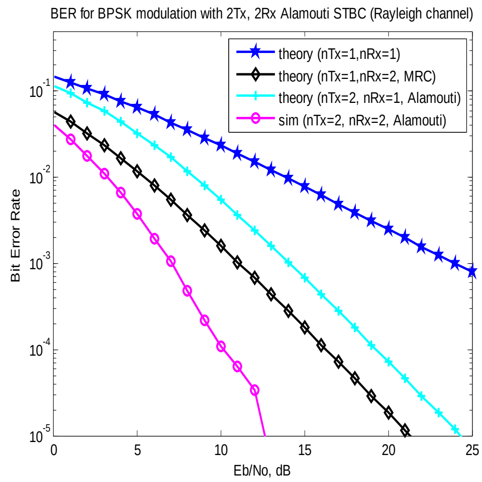
This graph shows the bit error rate for BPSK modulation with 2 Tx and 4 Rx antenna.

<u>Simulation using Beam forming Techniques</u>

Comparison between Bit error rate for BPSK modulation with 2 Tx and 2 Rx antenna and 2 Tx and 2 Rx antenna with various beam forming techniques.

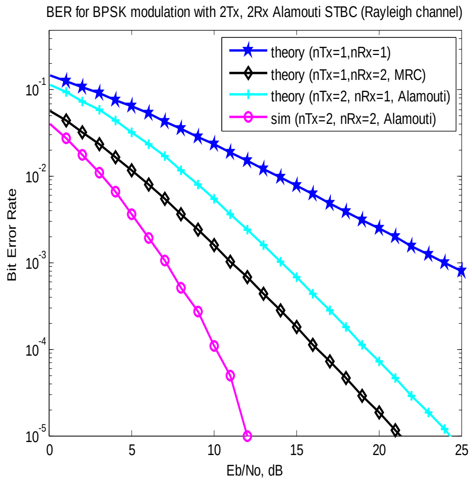


<u>Adaptive Beam forming</u>



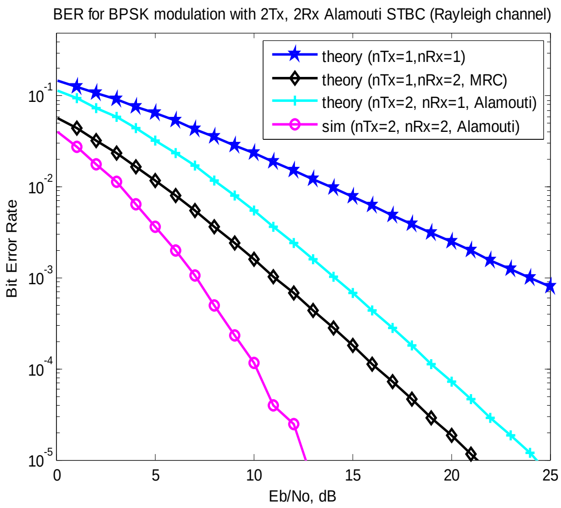
In this graph the value of SNR of 11 the value of BER y=4.9000e-05 but when we apply adaptive beam forming at same SNR then y=6.3000e-05, and the value of SNR of 12 y=3.0000e-05 but when we apply adaptive beam forming y=3.4000e-05, and also the value x=13 1.1000e-05 and by beam forming y=5.0000e-06 , the value of SNR of 15 y=2.0000e-06 and also the value of snr at point of x=16 y=0 whereas when we apply beamforming y=2.0000e-06 respectively.

Beam a signal with random noise



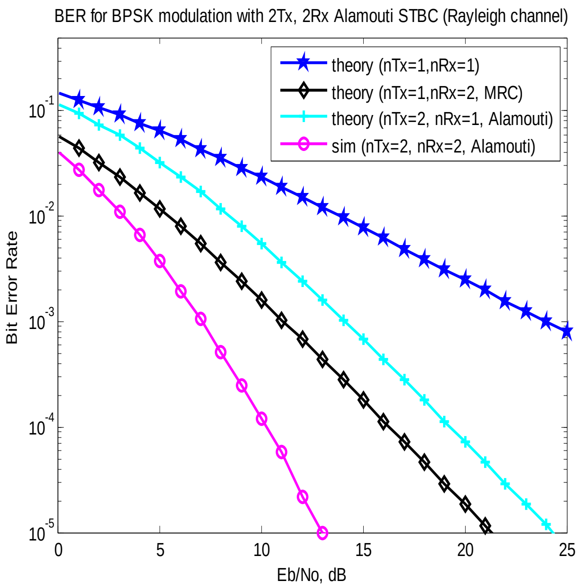
In this graph the value SNR of 9 then value of BER y=2.4300e-04 but when we beam a signal with random noise at point y=2.1900e-04, and the value SNR of 11 y= y=4.9000e-05 but when we beam a signal with random noise y=5.0000e-05, and also the value SNR of 13 y=1.1000e-05 and by beam forming y=5.0000e-06, and also at snr x=15 y=1.0000e-06 but by using Beamforming y=2.0000e-06 and also the value of SNR at point of x=16 y=0 whereas when we apply Beamforming y=2.0000e-06 respectively.

Broadband normal beam forming



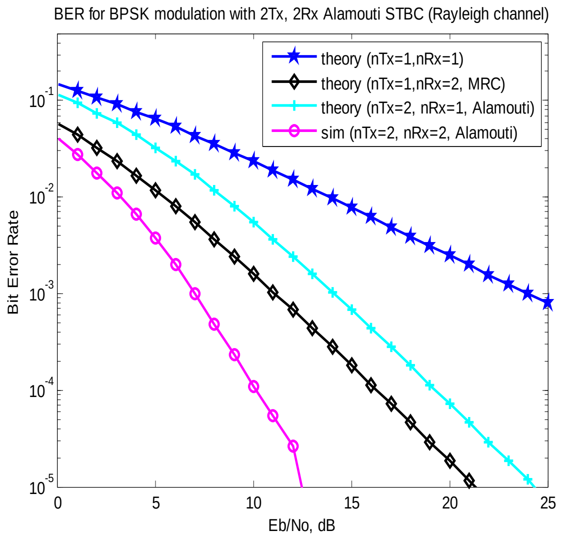
In this graph the value SNR of 13 the value of BER y=1.1000e-05, but when we broadband normal beam forming at point 13 the value of BER y=6.0000e-06 and also the value SNR of 15 then BER value y=1.0000e-06, but when we broadband normal beam forming at SNR of 15 then y=2.0000e-06 respectively.

Taylor Beam forming



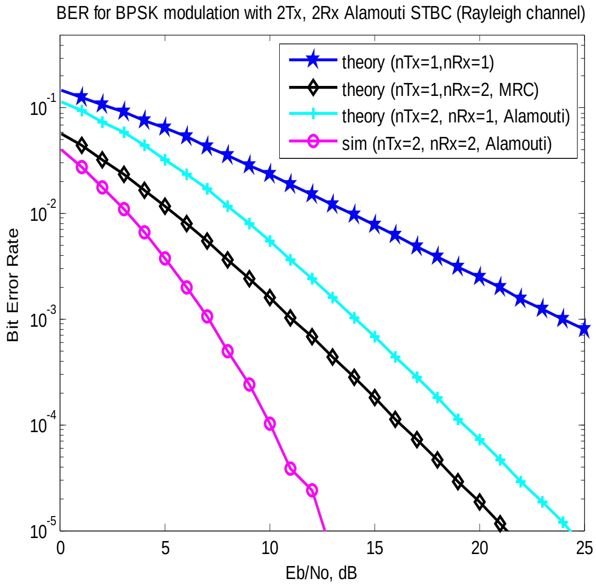
In this graph the value SNR of 11 y=4.9000e-05 but when we apply taylor beam forming technique y=5.0000e-05, and also the value SNR of 13 y=1.1000e-05 and by beam forming y=6.0000e-06,and at point of x=14 then y=5.0000e-06 but by applying beam forming y=6.0000e-06,and also at the value SNR of 15 then y=1.0000e-06 but by using Beamforming y=2.0000e-06 and also the value SNR of 16 y=0 whereas when we apply beam forming y=6.0000e-06 respectively.

Taylor window Beam forming



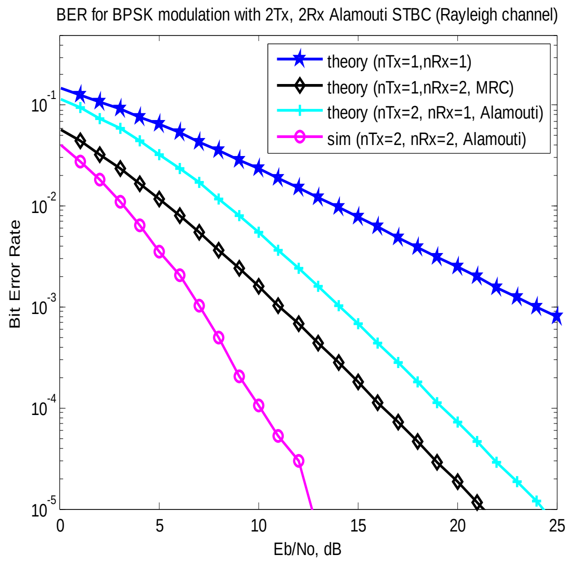
In this graph the value SNR of 11 y= y=4.9000e-05 but when we apply taylor window beam forming technique y=5.5000e-04, and also the value SNR of 13 y=1.1000e-05 and by beam forming y=3.0000e-06, ,and also at the value SNR of 15 then y=1.0000e-06 but by using beamforming y=2.0000e-06 respectively.

Transmit beam with QAM



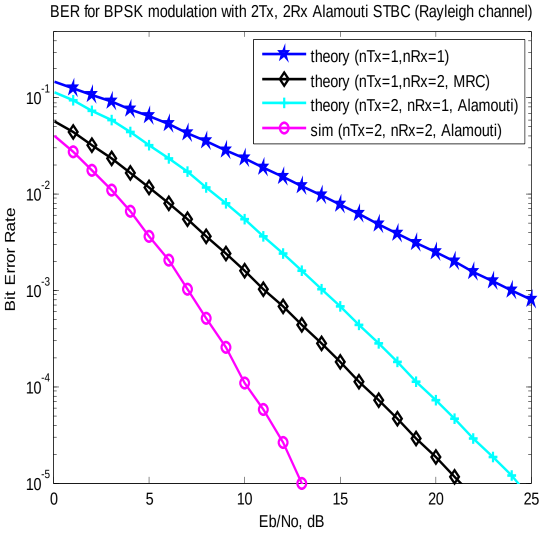
In this graph the the value SNR of 11 y= y=4.9000e-05 but when we use transmit beam with QAM technique y=5.5000e-04 and also the value SNR of 12 then y=3.0000e-05 but by using Beamforming y=9.0000e-05 and also the value SNR of 13 y=1.1000e-05 and by beam forming y=3.0000e-06 respectively.

Bartlet beam forming



In this graph the value SNR of 11 y= y=4.9000e-05 but when we use bartlett beamforming technique y=5.2000e-05 and also the value SNR of 13 y=1.1000e-05 and by beam forming y=3.0000e-06 and the value SNR of 14 then y= 5.0000e-06 and also the value SNR of 15 then y=1.0000e-06 but by using beamforming y=2.0000e-06 and also at the value SNR of 18 y=0 whereas by using beamforming y= and also at snr value the value SNR of 15 then y=1.0000e-06 but by using beamforming y=2.0000e-06 respectively.

Transmit Beamforming



In this graph the value SNR of 11 y= y=4.9000e-05 but when we use transmit beamforming technique y=5.8000e-05 and also the value SNR of 15 then y=1.0000e-06 but by using beamforming y=4.0000e-06 and also the value SNR of 16 y=0 whereas by using beamforming y=1.0000e-06 and also the value SNR of 15 then y=1.0000e-06 but by using beamforming y=2.0000e-06 respectively.

V. Conclusion

When data is transmitted over a data link, there is a possibility of errors being introduced into the system. In such case if errors are introduced into the data, then the integrity of the system may be compromised. In this research, we have attempted to provide a clear image of improving bit error rate of 4*4 MIMO system by various beam forming techniques. Firstly we improved BER by adding 2 transmit and 4 receive antenna and secondly improve BER by using various beam forming techniques. This results shows that improvement in bit error rate based on various beam forming techniques using MATLAB codes.

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