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BER based Performance Analysis of 4x2 MIMO Diversity with Encoder and Interleaver for BPSK, QPSK and QAM

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ABSTRACT
The MIMO technology with modulation techniques provides high bit rate, spectral efficiency and helps to mitigate ISI in wireless environment. In case of fading channel the BER increases, hence channel coding technique with interleaving is used to improve the performance in wireless communication. In this paper convolution coding along with matrix interleaving is used to enhance the system performance for different modulation techniques. The modeling and simulation of MIMO diversity system is carried out and the BER performance of interleaving, encoder and simple MIMO diversity is compared.

General Terms
Diversity techniques, BER, SNR, Space Time Block Codes

Keywords
MIMO diversity; Encoder; Matrix Interleaving; BPSK; QPSK; 8QAM; 16QAM

1. INTRODUCTION
Digital communication using multiple-input–multiple output once in a while called a "volume-to-volume" wireless connection, has as of late developed as a standout amongst the most critical specialized achievements in advanced correspondences. The innovation figures conspicuously on the rundown of later specialized advances with a possibility of determining the bottleneck of activity limit in future Internet-intensive wireless systems. Maybe considerably additionally surprising is that only a couple of years after its development the innovation appears to be ready to infiltrate substantial scale guidelines driven business remote items and systems for example, broadband remote access frameworks ,Wireless Local Area Network, third-generation systems and past. MIMO frameworks can be characterized essentially. Given a discretionary wireless correspondence framework, we consider a connection for which the transmitting end and in addition the less than desirable end is outfitted with numerous receiving wire components [1].

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2. NOISE AND INTERFERENCE
2.1 Bit Error Rate (BER)
The bit error rate or bit error ratio (BER) is the number of bit errors divided by the total number of transferred bits during a studied time interval. BER is a unit less performance measure, often expressed as a percentage [6].

2.2 Signal-to-Noise Ratio (SNR)
SNR is defined as the ratio between signal power to noise power and it is normally expressed in decibel (dB). The mathematical expression of SNR is

$$SNR=10\log\frac{\text{signal power}}{\text{noise power}}\text{ db} \qquad (1)$$

2.3 Energy Bit per Noise Ratio (Eb/No)
Eb/N0 (the energy per bit to noise power spectral density ratio) is an important parameter in digital communication or data transmission. It is a normalized signal-to-noise ratio (SNR) measure, also known as the "SNR per bit"[6].

3. PRINCIPLES OF SPACE-TIME (MIMO) SYSTEMS
Consider the multi antenna framework chart in Fig. 1. A compressed digital source as a binary data stream is encouraged to a rearranged transmitting block including the capacities of error control coding and (perhaps joined with) mapping to complex modulation symbols (quaternary phase shift keying, M-QAM, and so forth.). The last creates a few separate symbol streams which extend from not-dependent to halfway redundant to completely redundant. Each is then mapped onto one of the various transmitting antennas. Mapping may incorporate linear spatial weighting of the receiving wire components or straight reception apparatus space–time preceding. After upward frequency change, separating and enhancement, the signals are dispatched into the remote channel. At the recipient, the signals are caught by conceivably various antennas and demodulation and remapping operations are performed to recuperate the message. The level of insight, unpredictability, and from the earlier channel information utilized in selecting the coding and antenna mapping calculations can fluctuate an incredible arrangement relying upon the application. This decides the class and execution of the multi antenna arrangement that is executed. In the routine smart antenna phrasing, just the

transmitter or the receiver is really furnished with more than one component, being ordinarily the base station , where the additional cost and space have so far been seen as all the more effectively moderate than on a little telephone handset. Generally, the knowledge of the multiple antenna framework is situated in the weight determination calculation as opposed to in the coding side despite the fact that the improvement of space–time codes is changing this view [1].

Basic straight radio wire exhibit joining can offer a more dependable interchanges join within the sight of unfriendly proliferation conditions, for example, multipath blurring and impedance. A key idea in savvy reception apparatuses is that of beam forming by which one expands the normal sign to-commotion proportion (SNR) through centering vitality into wanted bearings, in either transmit or receiver. Indeed, on the off chance that one gauges the reaction of every antenna element to a given fancied sign, and potentially to obstruction signal(s), one can ideally consolidate the components with weights chosen as a component of every component reaction. One can then amplify the normal coveted sign level or minimize the level of different segments whether clamor or co-channel obstruction. Another intense impact of savvy radio wires lies in the idea of spatial assorted qualities. Within the sight of irregular blurring brought on by multipath engendering, the likelihood of losing the sign vanishes exponentially with the quantity of decorrelated radio wire components being utilized. A key idea here is that of assorted qualities request which is characterized by the quantity of decorrelated spatial branches accessible at the transmitter or beneficiary. Whenever joined together, influences of shrewd reception apparatuses are appeared to move forward the scope range versus quality tradeoff offered to the remote client [7]. As endorser units (SU) are bit by bit developing to turn into refined remote Internet access gadgets as opposed to simply pocket phones, the stringent size and intricacy limitations are turning out to be to some degree more casual. This makes various receiving wire components handsets a plausibility at both sides of the connection, despite the fact that pushing a great part of the handling and cost to the system's side (i.e., BTS) still bodes well. Plainly, in a MIMO join, the advantages of customary shrewd receiving wires are held subsequent to the advancement of the multiple antenna signals is completed in a bigger space, subsequently giving extra degrees of opportunity. Specifically, multiple input multiple output(MIMO) frameworks can give a joint transmit-get assorted qualities pick up, and additionally a cluster pick up upon intelligible joining of the radio wire components (accepting earlier channel estimation)

In actuality, the benefits of multiple-input multiple-output are much more central. The basic numerical nature of multiple-input multiple-output, where information is transmitted over a framework instead of a vector channel, makes new and colossal open doors past simply the additional assorted qualities on the other hand cluster pick up advantages. This was appeared in [8], where the creator indicates how one may under certain conditions transmit MIN(M,N) free information streams all the while over the Eigen modes of a lattice channel made by N transmission and M receiving antennas

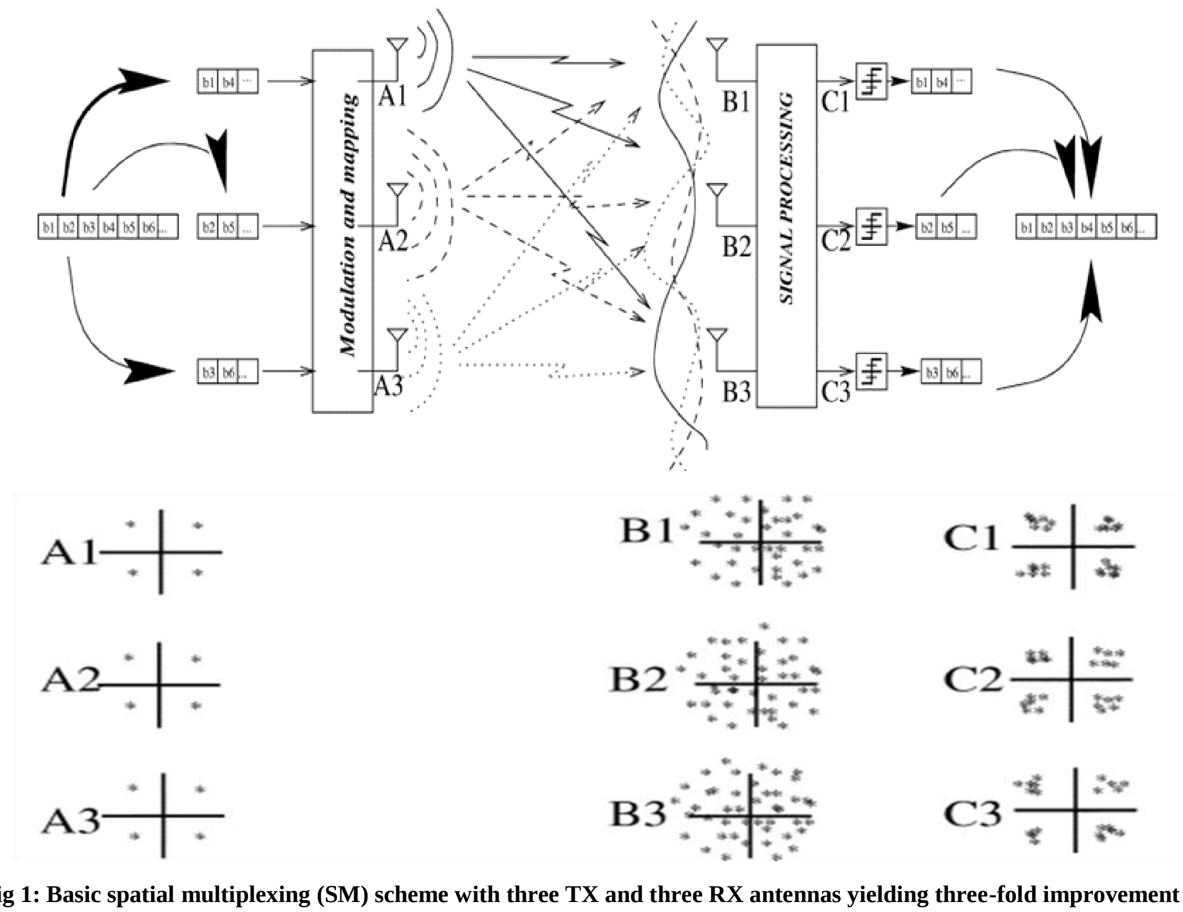

Fig 1: Basic spatial multiplexing (SM) scheme with three TX and three RX antennas yielding three-fold improvement in spectral efficiency. Ai, Bi, and Ci represent symbol constellations for the three inputs at the various stages of transmission and reception

4. IMPLIMENTATION MODEL

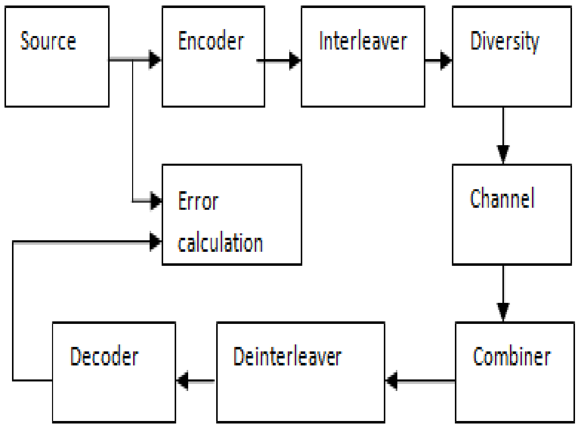

Fig 2: Block Diagram of MIMO Diversity using Encoder and Interleaving

4.1 Coding Techniques

Channel coding express the source data over the channel in a way that minimizes the error likelihood in translating by including the redundant bits deliberately. Channel coding is more essential over the remote channels; the bit error rate gets decreased at final reception. Channel coding should be possible by error-detecting or error correcting codes [9].

There are two essential methodologies of including structured redundancy utilized for controlling errors

a. Automatic Repeat Request (ARQ)

b. Forward Error Correction (FEC)

ARQ uses equality bits or repetitive bits for checksum added to the information to identify a error. The receiving terminal does not endeavour to redress the error dependably; rather it asks for the transmitter to retransmit the information. Consequently a two way connection is required amongst transmitter and recipient. This identification procedure sends an acknowledgement (ACK) or not acknowledgement (NAK) back to the transmitting hub to demand retransmission.

FEC utilizes repetitive bits added efficiently to recognize and rectify the error autonomously. These plans don't send ACK/NAK signals. Here just a restricted connection is adequate for appropriate correspondence; error taking care of is completely done by the receiver.

Essentially there are two sorts of codes when all is said in done

a. Error-Detecting Codes: - These kinds of codes are basically like, parity check, LRC-VRC check, and CRC check.

b. Error-Correcting Codes:- These are mainly used in wireless communication and are categorized as follows:

1. Block Codes:
   i. Hamming code
   ii. Bose-Chaudhary-Hocquenghem (BCH) codes
   iii. Reed-Solomon codes
2. Convolutional Codes
3. Turbo Codes:
   i. Block/ product turbo codes (BTC or PTC)
   ii. Convolutional turbo codes (CTC)

4.1.1 Convolutional Coding

The major utilization of Convolutional codes is that they are utilized to enhance the execution of remote connections and are utilized as a part of a large portion of most recent versatile systems. A Convolutional encoder is called so since it performs a convolution of the input stream with the encoder's impulse response. M bit data signal to be encoded is changed into a n-bit symbol where m/n is the code rate [10]. Essentially used to accomplish a dependable information exchange, these are more intense for blunder remedy than block codes

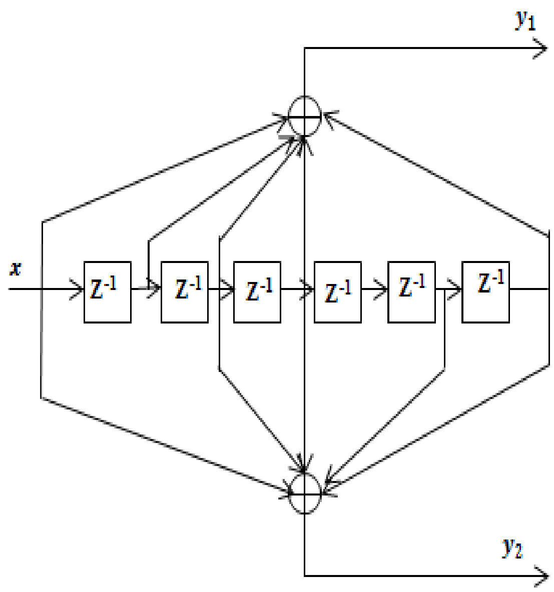

Fig. 3: Convolutional Encoder

The data bits input to shift registers and the output bits are acquired by modulo-2 addition of the input data bits and the elements of the shift registers. The encoder can be represented in a few distinctive yet identical ways [10].

4.2 INTERLEAVER

Interleaving is utilized to adapt to the channel noise, for example, burst errors which results because of blurring channel. The interleaver modifies input information such that successive information are part among various squares. At the receiver side, the interleaved information is re-arranged once again into the first arrangement by the de-interleaver. Interleaving can be utilized in digital information transmission to alleviate the impact of burst errors. At the point when an excessive number of mistakes exist in one code word, because of a burst blunder, the decoding of a code word is impossible accurately. To diminish the impact of burst blunder, the bits in one code word are interleaved before being transmitted. At the point when interleaving happens, the place of bits will change, which implies that a burst blunder can't exasperate a colossal piece of one code word

Transmission without Interleaving [11]:

Error-free message: aaabbbcccdddeeefff

Transmission with a burst error: aaabbbc_____deeefff

In the above case, the code-word ccdd is altered, so either it cannot be decoded at all or it might be decoded incorrectly.

Transmission with Interleaving:

Error-free codeword: aaabbbcccdddeeefff

Interleaved: abcdefabcdefabcdefabcdef

Transmission with a burst error: abcdefab___fabcdef

Received code words after de-interleaving: aaabbbcc_dd_ee_fff

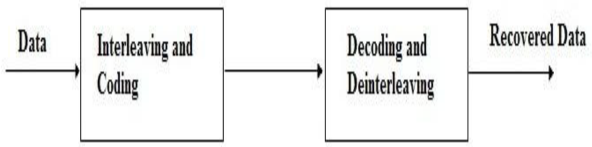

Fig. 4: Interleaving

4.2.1 Matrix Interleaving

Customarily, interleaving is utilized to spread out the errors happening in bursts like those showed in blurring or fading channels [10]. In such manner, network interleaving where bits are bolstered in a framework line by line and read out segment by segment (column by column), is normally actualized[11].

4.3 MODULATION TECHNIQUES

4.3.1 BPSK Modulation

BPSK is the least complex type of PSK. It utilizes two stages which are isolated by 180° thus can likewise be termed 2-PSK. For BPSK balance the channel can be displayed as

$$y=ax+n \quad (1)$$

where, y is the arrived signal at the input side of the BPSK collector, x is the modulated information transmitted through the channel , a will be a channel amplitude scaling component for the transmitted sign normally 1'n' is the Additive White Gaussian Noise(AWGN) arbitrary variable with zero mean and variance σ2. The benefit of BPSK is that it requires the least C/N proportion. The downside is that the information rate accomplished utilizing BPSK is low

4.3.2 QPSK Modulation and Demodulation

QPSK is essentially two BPSK links working on the same channel with their carrier signals in phase quadrature. In this way the BER of a QPSK remain same as BPSK. In the meantime the information rate is multiplied. The main punishment we pay is regarding C/N proportion. QPSK requires 3 dB more C/N proportion than BPSK.

4.3.3 Quadrature Amplitude Modulation (QAM)

The two carrier waves, usually sinusoids, are out of phase with each other by 90° and are thus called quadrature carriers or quadrature components The modulated waves are summed, and the resulting waveform is a combination of both phase-shift keying (PSK) and amplitude-shift keying (ASK), or (in the analog case) of phase modulation (PM) and amplitude modulation[6] .

5. RESULTS AND DISCUSSION

Based on communication blocksets of simulink model data is generated by using 4x2 MIMO diversity, Bit error rate is calculated using encoder and interleaver for different modulation techniques such as BPSK, QPSK, 8QAM, 16QAM.

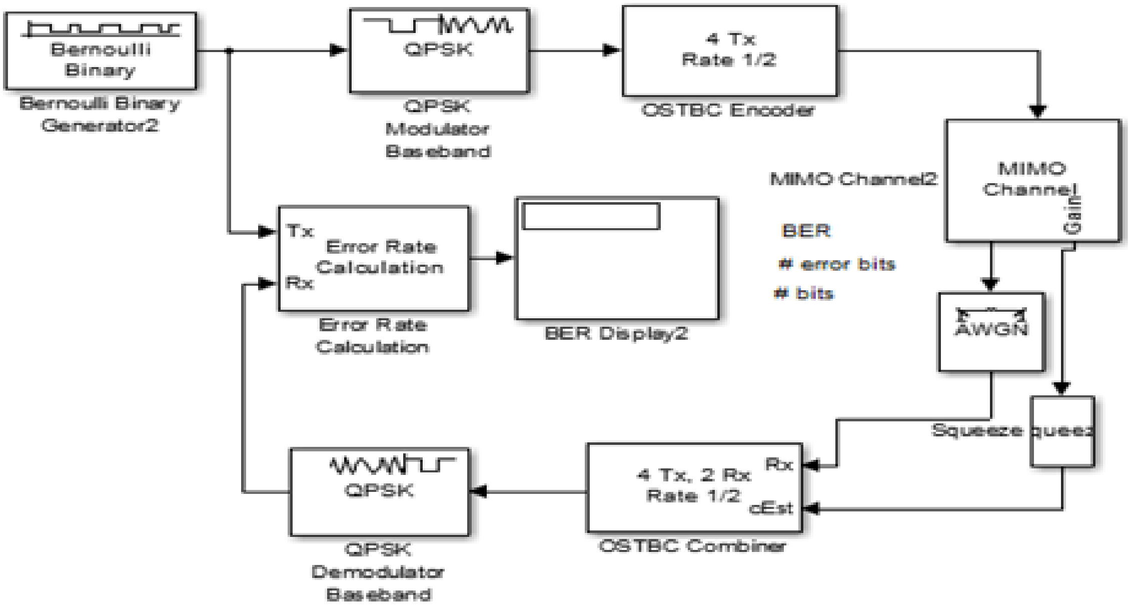

Fig 5: Implementation model of 4x4 MIMO Diversity using SIMULINK model

In this existing research the BER performance is evaluated using simulink platform by using communication blocksets. To support the experiments the results are evaluate by using Bit Error Rate calculator. The results were calculated using different units. For examples, modulation, modulation with 4x2 MIMO, interleaver with 4x2 MIMO and, encoder with MIMO diversity.

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Table 1 4x2 MIMO Diversity based Bit Error Rate Calculation

	BIT ERROR RATE (%)			
SNR	BPSK	QPSK	8QAM	16 QAM
1	0.0247	0.1458	0.0494	0.0617
2	0.0156	0.1084	0.0307	0.0376
3	0.0089	0.0766	0.0174	0.0219
4	0.0049	0.0497	0.0090	0.0115
5	0.0021	0.0314	0.0044	0.0060

This table shows the results of BER with the variation of SNR for 4x2 MIMO diversity for different modulation techniques. The BER is increases with the increasing value of SNR. BPSK modulation Technique gives the best result among all other techniques.

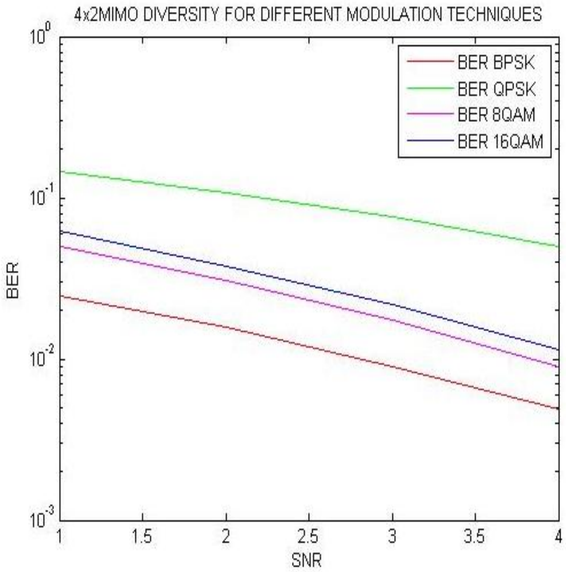

Fig.6: The graph of MIMO Diversity for different Modulation Techniques

Table 2: BER Calculation for 4x2 MIMO using Convolution Encoder

	BIT ERROR RATE (%)			
SNR	BPSK	QPSK	8QAM	16 QAM
1	0.0025	0.2709	0.0477	0.0962
2	0.0007	0.1759	0.0190	0.0499
3	0.0002	0.1154	0.0072	0.0247
4	0.0000	0.0501	0.0025	0.0105
5	0.0000	0.0206	0.0000	0.0042

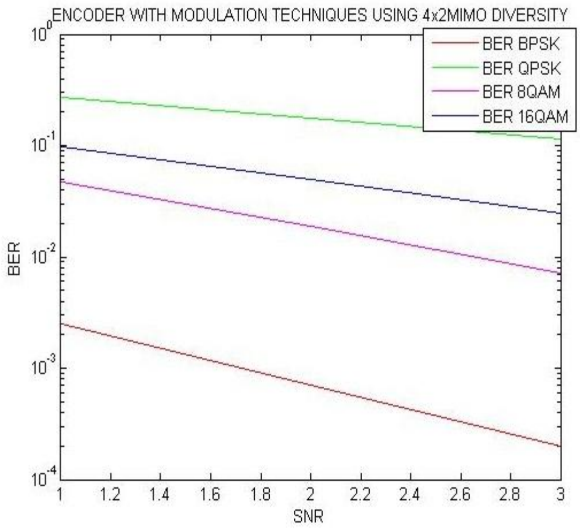

Fig 7: The graph of 4x2 MIMO Diversity with Convolution Encoder for Different Modulation Schemes

Table 3: BER Calculation for 4x2 MIMO using Interleaver

	BIT ERROR RATE (%)			
SNR	BPSK	QPSK	8QAM	16 QAM
1	0.0252	0.1460	0.0479	0.0612
2	0.0153	0.1089	0.0306	0.0387
3	0.0091	0.0771	0.0178	0.0217
4	0.0047	0.0505	0.0097	0.0114
5	0.0023	0.0314	0.0048	0.0061

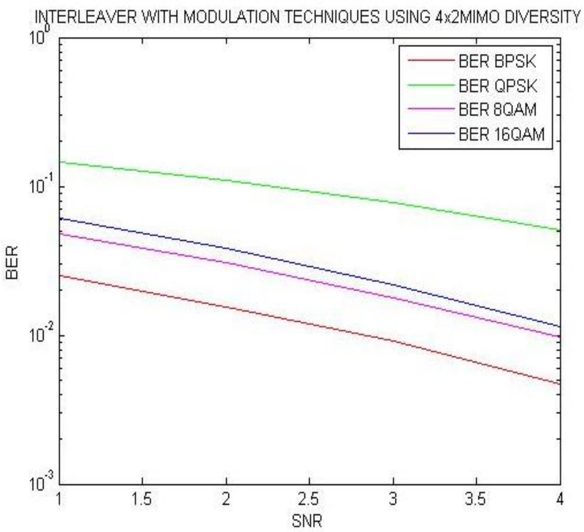

Fig. 8: The graph of MIMO Diversity with Matrix Encoder for Modulation Schemes

Table 4: BER Performance for MIMO Diversity with Interleaver and Encoder

	BIT ERROR RATE (%)			
SNR	BPSK	QPSK	8QAM	16 QAM
1	0.0015	0.2800	0.0343	0.0906
2	0.0000	0.1929	0.0132	0.0484
3	0.0000	0.0970	0.0031	0.0233
4	0.0000	0.0396	0.0006	0.0083
5	0.0000	0.0153	0.0000	0.0041

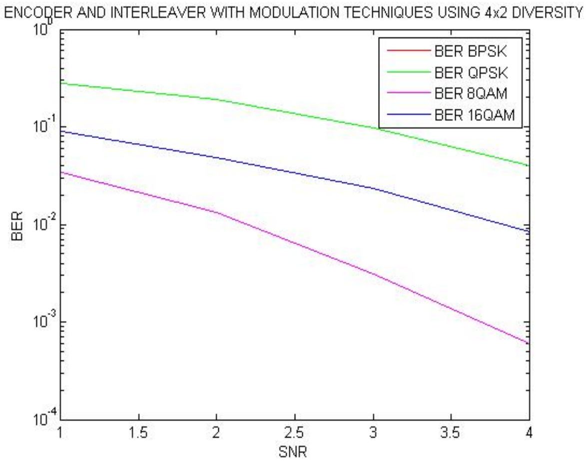

Fig 9: Plot the Graph of 4x2 MIMO Diversity with Convolution Encoder and Matrix Interleaving for Modulation Schemes

6. CONCLUSION

To get the performance of BER for different sets of simulink models above four tables are evaluated for 4x2 MIMO diversity .Bit error rate performance having a falling trend with the increasing values of signal to noise ratio. The results are performed for simple 4x2 MIMO, MIMO with encoder scheme, MIMO with matrix interleaver and MIMO with both matrix interleaver and convolution encoder for different modulation schemes. In case of BPSK and 8-QAM the 4x2 MIMO with both encoder and interleaver perform best then other schemes, in case of QPSK simple MIMO with modulation techniques give good result but MIMO with encoder and interleaver gives a more falling trend .In case of 16-QAM 4x2 MIMO with matrix interleaver perform good with lower rate of bit error

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