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Normalized Least Mean Square Channel Estimation for MIMO-OFDM System by using RAYLEIGH Fading

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Abstract: ***With the rapid growth of digital communication in recent year the need for high speed data transmission is increased. OFDM is promising solution for achieving higher data rate in mobile communication network. A multiple input multiple output (MIMO) communication system combined with orthogonal frequency division multiplexing (OFDM) modulation techniques can archive high data rate transmission over broadband wireless channel. The paper is amid at analyzing the BER performance of the MIMO OFDM system for Rayleigh fading channel along with a simulation channel using different modulation techniques. Also the result of the analysis suggest for the better techniques in order to improve the BER characteristics of the MIMO-OFDM system.***

Keywords: **MIMO, OFDM, Massive MIMO, QPSK, PSK, MPSK, QAM, Rayleigh Fading.**

I. INTRODUCTION

Orthogonal frequency division multiplexing (OFDM) Technology use high data rate in wireless communication and OFDM can be used in network conjunction with a multiple – input multiple output (MIMO) transmitter and receiver both to increase the diversity domain.

The usage of multiple antennas at both end of a wireless link hold the potential to radically improve the spectral efficiency and link reliability in upcoming wireless communication system. MIMO-OFDM is considering a technology in high data rate system such as 4G IEEE.802.11n, IEEE802.16. In this paper we will improve mainly capacity of communication network, channel estimation LS and MSE algorithm The main algorithm that will be enhance in paper is the LS and MSE for orthogonal frequency division multiplexing (OFDM) system and its low rank version the proposed channel estimation method required the statics knowledge of the channel in advance. A new wireless network technology gained great popularity for its capacity of high rate transmission and its robustness against inter-symbol interference and other channel impairment. This combination of MIMO-OFDM is a very promising feature since OFDM able to sustain of more antennas since OFDM able to sustain of more antennas since it simplify equalization in MIMO system. Usually in OFDM , fading is consider as a problem in wireless network but MIMO channel use the fading to increase the capacity of the entire communication network.

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As on demand for high-data rate multimedia groaning, several approach such as increasing modulation order or employing multiple Antennas at transmitter side and receiver end. It achieves by higher spectral efficiency and link reliability because of these properties. MIMO is a current theme of international wireless research. In a digital system the capacity for a channel of bandwidth W perfected by white thermal noise of power N, with an average transmits power of P is given by-

$$C = B\log_2(1+s/n) \quad \ldots\ldots\ldots\ldots\ldots\ldots[1.1]$$

The gradual evolution of mobile communication system follow the request for high data rates measured in bit/sec.

II. MIMO MODEL

We have show the model of MIMO in fig.-1 incoming data stream travels through serial to parallel converter and all the stream as modulated by using BPSK, QPSK, 16QAM, 64QAM . after that spatial multiplexing comes into picture now all the turbulent environments and then collected by antenna has at receiver end. Brief show and explain shortly of all the techniques and channel model is given below.

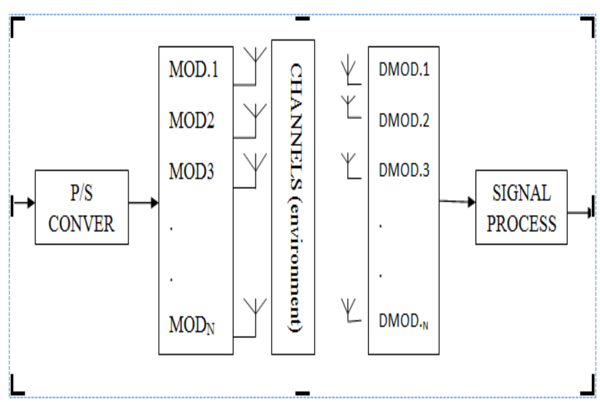

Fig 1. MIMO Model

A. Modulation Techniques: - In this part massage bit are encoded by transmitter a single pulse in one of 2M possible time shifts. This is repeat every T second, such that the transmitting bit rate is M bit per second. There are modulation techniques used for it that are binary phase shift modulation (BPSK), etc.

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B. Spatial Multiplexing:-The number of transmit- receiver antenna pair or min (M_{R-} $M_{T)}$ increase in the transmission rate for the same bandwidth and with number of additional power expenditure. It is only possible in MIMO channel. The bit steam is split in to two half rate bit stream, modulated and transmitted simultaneously from both the antenna. The receiver has knowledge of the channel it provides receiver diversity but system has no transmit diversity since the bit stream are complete difference data. Thus spatial multiplexing increase the transmission rate proportionally with the number of transmit – receiver antenna pairs this concept can be extended to MIMO-MU. In this a case, two users transmit their respective information simultaneously to the base station equipped with two antennas. The base station can likewise transmit two signals with spatial filtering so that each user can decodes his own signal correctly. Allows capacity to increase proportionally to the number of antenna at base station and the number of user. MIMO-OFDM and spread MIMO-OFDM give more capacity than conventional MIMO in presence of multipath and based on their results MIMO-OFDM and spread MIMO-OFDM would be similarly impacted by multipath. This reason able since OFDM with long enough cyclic prefix is a powerful mean to mitigate multipath. The combination MIMO-OFDM is very natural and beneficial since OFDM enables support of more antennas and larger bandwidths.

III. MIMO-OFDM

A. OFDM system model:-OFDM system model diagram, the data bits inserted from the source are firstly mapped (BPSK, QPSK, 16-QAM,64-QAM) using modulation techniques and after that convert from serial to parallel using convertor.

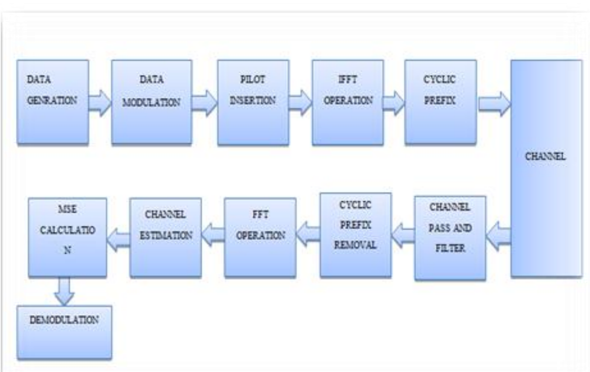

Fig.2 Block Diagram of a Base-band OFDM

Now N number of subcarrier are there and each sub-carrier consist of data symbol X(k) (k = 0,1,……N-1), Where k show the sub-carrier are provide to inverse fast Fourier transform (IFFT) block after transformation, the time domain OFDM signal at the output of the IFFT can be written as:

$$X(n) = \sum_{k=0}^{N-1} X(k) \exp\left(\frac{2\pi kn}{N}\right)$$

$$0 < n < N-1 \qquad \text{……….[3.1]}$$

Transceiver System

After done cyclic prefix added to mitigate the ISI effect. We get signal $X_{cp}(n)$, which send parallel to serial then frequency selective multi-path fading channels and a noisy channel with AWGN noise we used Rayleigh fading channel. The received signal can be given by

$$Y_g(N) = X_g(n)*h(n) + w(n),$$

$$0<n<N-1 \text{………[3.2]}$$

Where W(n) is additive white Gaussian noise sample and h(n) is the discrete time channel impulse response. At the receiver, firstly serial to parallel conversion occurs and cyclic prefix removed. After removing the cyclic prefix, the output of the FFT in frequency domain signal on the K^{th} receiving sub-carrier can be express as:

$$Y(k) = \frac{1}{N}\sum_{k=0}^{N-1} Y(n) \exp\left(\frac{j2\pi kn}{N}\right)$$

$$Y(k) = X(k)H(k) + w(k)$$

$$0<k<N-1 \text{…………[3.3]}$$

Where W(k) is noise in time domain and H(k) is the channel frequency response.

B. MIMO system model: - In MIMO system is a channel path between each of the transmitter and each of the receiver antennas. If well spacing is there between the transmitting and the receiving antennas, then we achieved sufficiently un-correlation received signal.

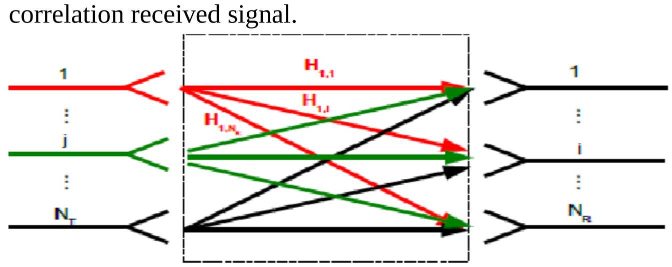

Fig.3 MIMO System line diagram

Let us assume an MIMO system N_T transmit antennas and N_R receive antenna as show in fig simplicity we consider only flat fading the fading is not frequency. MIMO technology will predominantly be used ion broadband system that exhibit frequency selective fading and symbol interference (ISI). The overall frequency selective channel is converted into a set of parallel flat fading channel which drastically simplifies the equalization task; however as the CP carrier redundant information it incurs a loss in spectral efficiency.

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IV. BIT ERROR RATE AND SIGNAL TO NOISE RATIO ANALYSIS

A. Bit Error Rate

In digital transmission number of bit errors is the number of receiving bit A signal data over a communication channel that has been changed because of noise, distortion, interference or synchronization redundancy of bit, The bit error rate or bit error ratio (BER) is defined rate of errors occur in a transmission system during a studied time interval. BER is a unit less quantity, often expressed as a percentage of the negative power. The definition of BER can be translated into a simple formula:

$$\text{BER} = \frac{\text{Number of erroe}}{\text{Total number of bit sent}}$$

Noise is the main enemy of BER performance. Quantization errors also reduce BER performance, through unclear reconstruction of the digital waveform. The precision of the analog modulation and demodulation process and the effects of filtering on signal and noise bandwidth also influence quantization errors.

Bit error rate of multiple input and multiple output (MIMO) orthogonal frequency division multiplexing (OFDM) system with carrier frequency offset and channel estimation error is analyzed in this paper. MIMO technology improves the wireless network capacity. This system is primary design for flat fading MIMO channel. So MIMO-OFDM although one can use frequency offset correction algorithm residual frequency offset can still increase the bit error rate (BER). The bit error rate is evaluated for multipath fading channel many frequency offset estimator haven been proposed. In real system neither the frequency offset nor the channel can be perfectly estimated. There for the residual frequency offset and channel estimation error impact the BER performance. The BER performance of MIMO system without considering the effect of both the frequency offset and channel estimation error. BER analysis of MIMO-OFDM, taking into consideration both the frequency offset and channel estimation error. The analysis exploits the fact that for unbiased estimation, both channel and frequency offset estimation error are zero-mean random variable.

B. Signal to Noise Ratio:

The SNR is the ratio of the received signal power over the noise power in the data transmission process of mobile communication network. SNR is inversely related to BER, that is high BER causes low SNR. High BER causes an increase in packet loss, enhance in delay and decrease throughput. SNR is an indicator use for measure clarity of the signal in a circuit or a wired/wireless transmission channel this unit is decibel (dB). The SNR is the ratio between the wanted signal and the unwanted background noise

$$\text{SNR} = \frac{P_{signal}}{P_{noise}}$$

A signal during the transmission is one of the crucial problems in wireless communication which need to be handled carefully. One of this problem is space time block code which is design and developed by keeping the multiple antenna system into consideration. The main aim of this work is to perform the analysis of the Signal to noise ratio (SNR) by changing the carrier frequency offset (CFO), timer and phase noise. Analysis has been carried out with the help of graph develop in the MATLAB environment. One more graph has been used which BER versus SNR for analysis point of view.

C. Calculation of BER and SNR

The transmit OFDM signal for the M_{th} symbol is given by the N-1 point complex modulation sequence:

$$X_m(n) = \sum_{K=0}^{N-1} X_m(K)\, e^{\frac{j2\pi nk}{N}} \text{.......[4.1]}$$

Where n ranges from 0 to N+Ng-1. Bit Error Rate can be determined with the help of E_0/N_0:

$$\text{BER} = 0.5 \times erfc(\sqrt{SNR}) \text{..............[4.2]}$$

SNR is exponentially decreasing. In this work three curves in the figure for different variance of phase noise. The SNR decreases with increasing value of the phase noise. This technique basically reduces the probability of getting an overall weak channel. one attempt has been made to derive the SNR (signal to noise ratio) and BER (Bit error rate) for different combination of MIMO system. How to impact a noise on carrier interference and channel response process in the MIMO system has been design and developing simulated and then analyzed. SNR Vs BER curve indicate the performance of the MIMO system can be improved by diversity gain. MIMO architecture has been studied and analysis.

V. CHANNEL ESTIMATION

In the communication network signal goes though a medium between transmitter and receiver, signal gets distorted or various noise added to signals, this to losses of signal, signal not reach at proper form at receiver end. Control the distortion of the signal use technique called channel estimation. Different way for channel estimation but fundamental concept are same use general algorithm, channel estimation for SISO and MIMO of noise and channel coefficient. The MSE of the LS channel estimation is computed optimal pilot sequence and optimal placement of the pilot tone we can write that this MSE are derived.

The MSE of the LS channel estimation is given by

$$\text{MSE} = \frac{1}{LN_t} \mathcal{E}\{\| h^q - h^q \|^2\} \qquad \text{........[5.1]}$$

$$\text{MSE} = \frac{1}{LN_t} \mathcal{E}\{\| \tilde{A}^{\dagger} \Xi^q \|^2 \qquad \text{........[5.2]}$$

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$$MSE = \frac{1}{LN_t} tr\{\tilde{A}^\dagger \mathcal{E}\{\Xi^q \Xi^{q*}\} \tilde{A}^{\dagger *}\} \quad ....[5.3]$$

For zero-mean white noise, we have $\mathcal{E}\{\Xi^q \Xi^{q*}\} = \sigma^2 n I p$. then the MSE can be written as

$$MSE = \frac{\sigma^2 n}{LNt} tr\left\{\left(\tilde{A}^H \tilde{A}\right)^{-1}\right\} \quad ....[5.4]$$

We can show that in order to obtain the minimum MSE of the LS channel estimation subject to a fixed power p dedicated for training, we require $\tilde{A}^H \tilde{A} = p I_{LN_t}$

The minimum MSE is give by

$$MSE\ min = \frac{\sigma_n^2}{p} \quad . ...[5.5]$$

In modern wireless communication systems, a combination of multiple-input multiple-output (MIMO) system with the orthogonal frequency division multiplexing (OFDM) technique can be used to achieve high data rate and better spectral efficiency. A Channel estimation technique using pilot carriers for multiple input multiple output (MIMO) systems. The channel estimation is carried out with conventional Least Square (LS) and Minimum Mean Square (MMSE) estimation algorithms.

This paper considers channel estimation and system performance for the uplink of a single-cells massive Multiple-input multiple-output (MIMO) system. Each receive antenna of the base station (BS) is assumed to be equipped with a pair of one-bit analog-to-digital converters (ADCs) to quantize the real and imaginary part of the received signal. We first propose an approach for channel estimation that is applicable for both flat and frequency-selective fading. The resulting channel estimator outperforms previously proposed approaches across all SNRs. We derive closed-form expressions for the achievable rate in flat fading channels assuming low SNR and a large number of users for the maximal ratio and zero force receivers that takes channel estimation error due to both noise and one-bit quantization into account. Numerical simulations indicate that the CML is well defined in the SNR range corresponding to practical applications. Oblique projections are well known for their applications in signal processing, especially in channel estimation. With this formulation, it is proved that the channel estimator is unbiased. This result is of importance; in particular, the channel estimate is proved to be an algebraic function whose inputs are the initial value and the means and variances of the received data. In block-type pilot based channel estimation, OFDM channel estimation symbols are transmitted periodically, in which all subcarriers are used as pilots. If the channel is constant during the block, there will be no channel estimation error since the pilots are sent on all carriers. For a fast fading channel, where the channel change between adjacent OFDM symbols, the pilots are transmitted at all times but with an even space on the subcarriers, representing a combination type pilot placement. Based on the assumptions such as perfect synchronization and block fading, a MIMO-OFDM system is design. In training based channel estimation algorithms, training symbols or pilot tones that are known to the receiver, are multiplexed along with the data stream for channel estimation. The idea behind above explained method is to develop knowledge of transmitted pilot symbols at the receiver to estimate the channel. For a block fading channel, where the channel is constant over a few OFDM symbols, the pilots are transmitted on all subcarriers in periodic intervals of OFDM blocks. The channel estimates from the pilot subcarriers are interpolated to estimate the channel at the data subcarrier.

A. Rayleigh Channel

The effects of multipath embrace constructive and destructive interference, and phase shifting of the signal. This causes Rayleigh fading. There is no line of sight (NLOS) path means no direct path between transmitter and receiver in Rayleigh fading channel the received signal can be simplified to:

$$R(n) = \sum h(n,\tau) s(n-m) + w(n) ....[5.6]$$

Where W(n) is AWGN noise with zero mean and unit Variance, h(n) is channel impulse response i.e.

$$h(n) = \sum \alpha(n) e^{-j\theta}(n) ....[5.7]$$

Where α(n) and (n) are attenuation and phase shift for N number of path. If the coherence bandwidth of the channel is larger than signal bandwidth, the channel is called flat; otherwise it is frequency-selective fading channel. In this paper, MIMO OFDM is simulated under frequency-selective fading channel. The Rayleigh distribution is basically the magnitude of the sum of two equal independent orthogonal Gaussian random variables and the probability density function given by-

$$P(z) = \frac{z}{\sigma^2} e^{\frac{-z^2}{e^2}} \sigma^2 \quad Z \geq 0 ....[5.7]$$

VI. SIMULATION AND RESULT

The simulation shown by using two equalization in MIMO OFDM system first is least square second is means square error and one fading channel are used that is Rayleigh fading channel, we have been used different modulation techniques i.e. BPSK, QPSK, PSK, QAM we analyze that the an effective method for data transmission in all of the modulation and for the channel in term of bit error rate for PSK at the BER value 10^{-4} we get SNR value 15 dB. The BER Performance of MIMO OFDM system has been analyzed for two scenarios, Also the affect of the different modulation techniques performance of MIMO-OFDM system is illustrated through the simulation results. After comparing the simulation result obtained by plotting Bit Error Rate (BER) against the Signal to Noise Ratio (SNR), there are two facts which are quite obvious and lead to

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conclusion. Secondly, the different modulation techniques also affect the BER performance of the system.

Firstly, defined all parameters then make function of MIMO - OFDM with 2-level Montecarlo. Now run this file with different QPSK order. Result graph is showing considerable improvement in bit error rate and signal to noise ratio. In table 6.1, simulation parameters are showing which is taken during the execution of MATLAB script. In this number of transmitter and number of receiver antenna keep change. Also set PSK modulation scheme from 4 to 256QPSK.

Table 1: Simulation Parameters

Parameter	Value
Number of blocks	1e2
Number of transmit antennas	64
Number of receive antennas	64
Number of subcarriers	128
Guard interval percentage	¼
PSK Modulation	4-256
Subcarrier space between two pilots	1
Signal to noise ratio	15 dB
Symbols	1000-2000

In table 1, simulation parameters are showing which is taken during the execution of MATLAB script. In this number of transmitter and number of receiver antenna keep change. Also set PSK modulation scheme from 4 to 256QPSK.

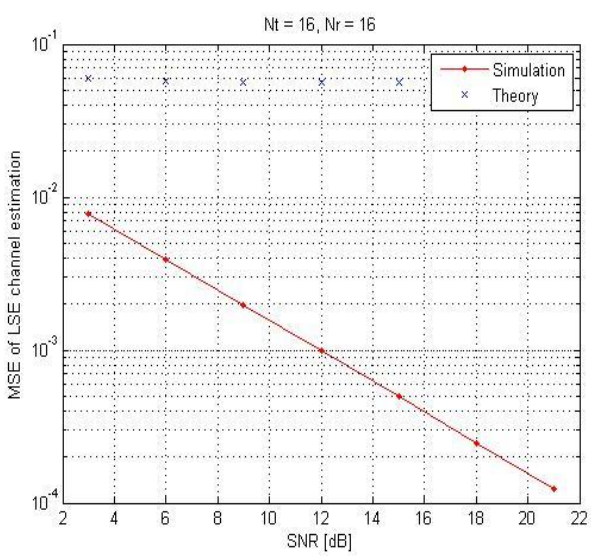

Fig 4. MSE of LS channel Estimation vs SNR graph for Tx=16 and Rx=16

In fig.4 make graph between signal to noise ratio and mean square error in here bandwidth value are 15 dB , 16- number of transmitter and receiver antennas maximum SNR is 22 dB and MSE is 10-4 Make channel estimation. This graph for Tx=4 and Rx= 2 to 16 showing output graph between bit error ratio and signal to noise ratio. Here modulation scheme is 4-PSk, after analyzing both graphs, we can say while SNR & BER both needed to significant then it is proposed less dimension MIMO i.e. 4x4 Transmitters and Receiver. Show output graph between bit error ratio and signal to noise ratio. Here modulation scheme is 16-PSk, after analyzing both graphs, we can say while SNR & BER both needed to significant then it is proposed less dimension MIMO i.e. 8x8 Transmitters and Receivers. When increase number of antennas in function change at output graph, on the antennas 16✕16 at a time BER goes to high at a constant value.

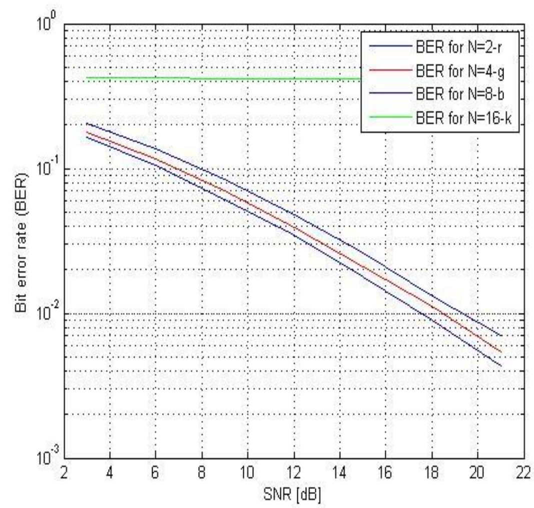

Fig 5: MSE of LS channel estimation vs SNR.

Various types of modulation techniques are used for reduce Bit Error rate in wireless communication network, number of modulation techniques with numbers of antenna show the graph in below-

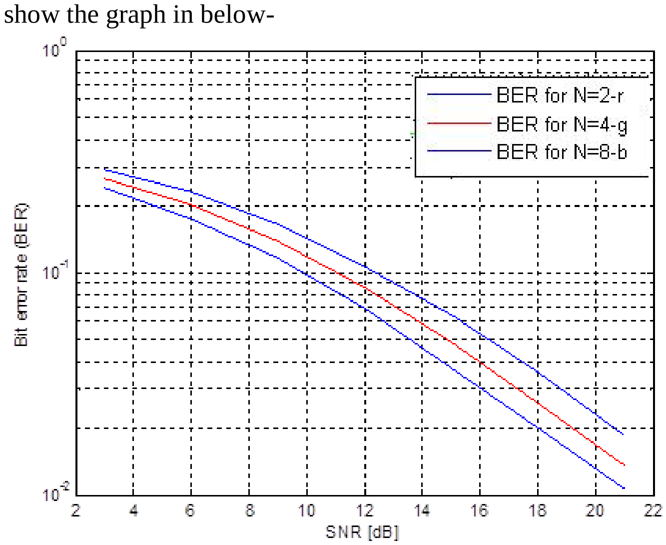

Fig 6. Bit error rate with uniform random distribution

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Figure 6.and 7 Result comparison of the proposed work. In this dissertation the comparison of the BER is carried out for the two different random distributions for the channel estimation of the MIMO –OFDM systems. It is found that the by using the proposed normal random distribution for the channel initialization and realization for the fading environment may significantly improve the performance when the number of antenna are increased for MIMO design as expected in the near future with the implementation if the 5G cellular Network.

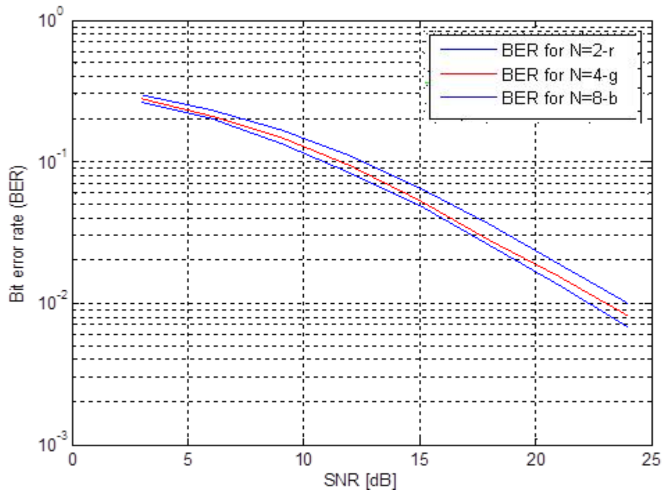

Fig 7. Bit error rate with normal random distribution

This can be observed form the Figure below that performance for uniform distribution degrades for higher MIMO size. But comparatively there is less variation in the performance with the normal distribution

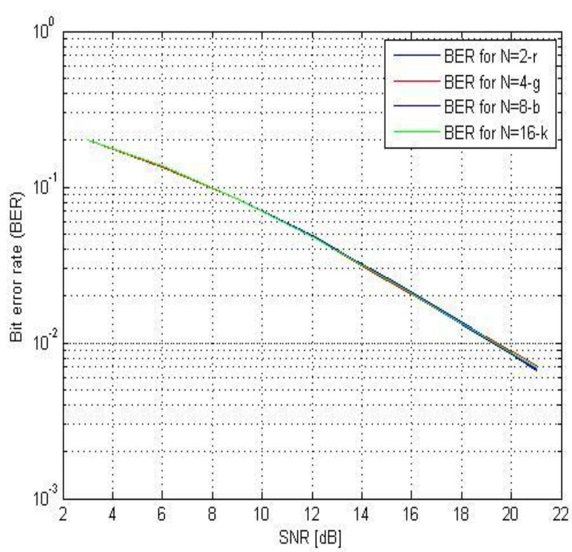

Fig 8. 16 -PSK modulation for 8✕ 8 antennas use both end (transmitter end and receiving end)

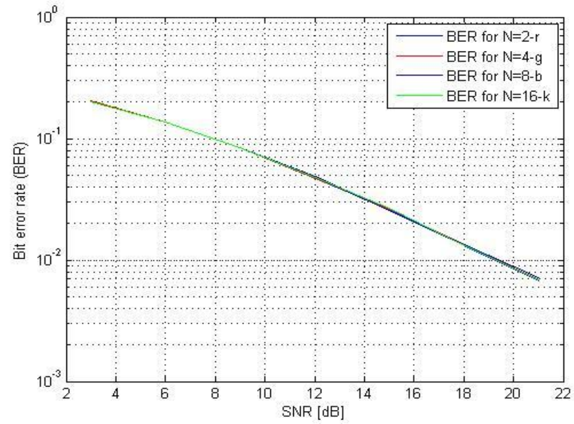

Fig 9.64 -PSK modulation for 8✕ 8 antennas use both end (transmitter end and receiving end)

VII. CONCLUSION

In this paper least square channel estimation scheme for MIMO OFDM system to obtain the minimum MSE of the LS channel estimate, increasing the number of transmit antenna require more pilot tone for training and hence decreases the efficiency. In this paper proposed scheme for improve the performance of communication Network BER under the different modulation and proposed for development of an MIMO-OFDM reconfigurable architecture , further possibility of improving the BER performance by developing new techniques to compensate ISI effect the OFDM channel given a good enhancement of the BER verses SNR and a good MSE. In fact it's required to improve this estimation with its low rank version by other scheme of modulation and this will be done in future work.

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