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Diversity Techniques using BPSK and QPSK Modulation in MIMO system under fading environment.

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***Abstract*:**

In this paper, performance analysis for different combining technique for receiver diversity in a MIMO system are presented. A general framework for diversity combining techniques in cooperative wireless communication system is also provided. Performance analysis of different diversity combining techniques i.e. Selection Diversity, Equal Gain Combining and Maximal Ratio Combining is calculated over Rayleigh fading channel for both BPSK and QPSK modulation. Monte Carlo simulations resulting in graphs showing the bit error rate v/s signal to noise ratio are provided to verify the results.

Index Terms- BER, QPSK, Fading, BPSK, SNR, Diversity.

I. INTRODUCTION

In digital communication system, the main objective is to receive data as similar as the data sent from the transmitter. Digital communications industry is continuously growing. Therefore, the applications of modulation techniques in digital communication continue to grow as well. This growth increases the need of automated methods of analyzing the performance of digital modulation types using the latest mathematical software.Each modulation technique has different performance in receiving diversity techniques. Diversity is the technique used to compensate for fading channel impairments. It is implemented by using two or more receiving antennas [1]. While Equalization is used to counter the effects of ISI. Diversity is usually employed to reduce the depth and duration of the fades experienced by a receiver in a flat fading channel. These techniques can be employed at both base station and mobile receivers. Spatial Diversity is the most widely used diversity technique. This paper focuses on comparative performance analysis of BPSK (Binary Phase Shift Keying) and QPSK (Quadrature Phase Shift Keying) modulation scheme in different spatial diversity techniques like equal gain combining (EGC), selection combining (SC), and maximal ratio combining (MRC). Comparative performance analysis is done on the basis of bit error rate (BER) and signal to noise ratio (SNR).The BER curves for BPSK and QPSK obtained after simulation are compared for given values of SNR [2].

Diversity combine the multiple replicas of transmitted signal at the receiver to increase the overall received SNR. The intuition behind this concept is to exploit the low probability of occurrence of deep fades in all the diversity channels to lower the probability of error and of outage. In this paper, we have taken the following conditions for analysis:

- There are N antennas at the receiver end and one antenna for transmitting the data.
- The channel is flat fading
- The channel experienced by each receiving antenna is randomly varying in time.
- The channel experience by each receiving antenna is independent from the channel experienced by other receiving antennas.
- On each receiving antenna, the noise n has the Gaussian probability density function with

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$$\mathbf{p(n)} = \frac{\mathbf{1}}{\sqrt{\mathbf{2\pi\sigma^2}}}\mathbf{e}^{\frac{-(\mathbf{n}-\mu)^2}{2\sigma^2}} \mathbf{with}\, \mu = \mathbf{0} \text{ and } \sigma^2 = \frac{\mathbf{N_0}}{\mathbf{2}}$$

Where μ is the mean and $\sigma^2$is the variance for Gaussian pdf. There are number of techniques for combining statistically independent faded signal components available at output of the coherent demodulators for transmitted symbol detection by the decision device. The diversity branches are summed up linearly in the linear combining method. Linear combining techniques include selective combining, equal gain and maximal ratio combining [3].

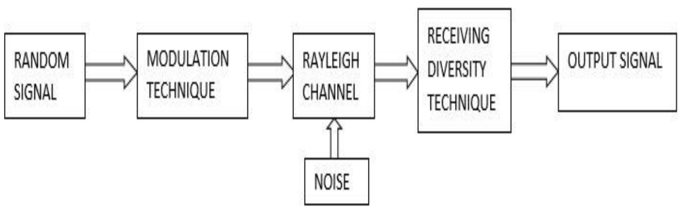

Fig: 1 Block Diagram

II. PERFORMANCE PARAMETERS

Bit Error Rate (BER)

The bit error rate or bit error ratio (BER) is the ratio of number of bit errors to the total number of transferred bits during a given time interval. In Wireless communication the number of bit errors is the number of received bits of a data over a communication channel that has been altered due to noise and interference [4]. The bit error probability P_b is given by

$$\text{Bit error rate } (P_b) = \frac{\text{Number of bits in error}}{\text{Total no. of transmitted bits}}$$

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

$$\text{SNR} = 10 \log \frac{\text{Signal Power}}{\text{Noise Power}} dB$$

III. DIGITAL MODULATION TECHNIQUES

Modulation is defined as the process by which the characteristics of carrier wave is changed according to the modulating signal and carrier isable to carry the message. In this paper we analyze the performance of two digital modulation techniques i.e. Binary Phase Shift Keying (BPSK) and Quadrature Phase Shift Keying (QPSK), on the basis of BER (bit error rate) achieved in receiving diversity techniques.

BINARY PHASE SHIFT KEYING (BPSK)

Binary phase shift keying (BPSK) is the most efficient of the three digital modulation i.e., ASK, FSK, PSK. Hence, binary phase shift keying (BPSK) is used for high bit rates. In BPSK, phase of the sinusoidal carrier is changed according to the data bit to be transmitted. Also, a bipolar NRZ signal is used to represent the digital data coming from the digital source [4-6].

QUADRATURE PHASE SHIFT KEYING (QPSK)

In communication systems, we have two main resources. These are the transmission power and the channel bandwidth. The channel bandwidth depends upon the bit rate or signaling ratef_b. In digital bandpass transmission, we use a carrier for transmission. This carrier is transmitted over a channel. If two or more bits are combined in some symbols, then the signaling rate will be reduced. Thus, the frequency of the carrier needed is also reduced. This reduces the transmission channel bandwidth. Hence, because of grouping of bits in symbols, the transmission channel bandwidth can be reduced [7].

IV. DIVERSITY COMBINING TECHNIQUES

SELECTION COMBINING

With selective diversity, one best signal is chosen based on the received signal strengths from the set of diversity branches. The receiver monitors the SNR value of each diversity branch and selects the one with the maximum SNR value for signal detection.Consider N number of independent fading signals received by multiple receiver antennas. There are N-branch receiver antennas. There are N-branch receivers comprising of coherent demodulators. The output of demodulators is

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presented to a logic circuit which selects the particular branch receiver output having the largest SNR value of received signal. The antenna chooses the best SNR among the received signals. In the figure 1, the receiver selects the signal having maximum SNR.In selection diversity, we will assume that the channel is a flat fading Rayleigh multipath channel and the modulation is QPSK. As each element is an independent sample of the fading process, the element with the greatest SNR is chosen for further processing. In selection combining therefore

$$\mathbf{w_k} = \begin{cases} \mathbf{1 \gamma_k = max_n\{\gamma_n\}} \\ \mathbf{0 otherwise} \end{cases}$$

Where $\mathbf{w_k}$ is weight of signal and $\boldsymbol{\gamma_k}$is Signal to Noise Ratio.

The overall SNR of the system is given by equation$\boldsymbol{\gamma} = \mathbf{max_n\{\gamma_n\}}$

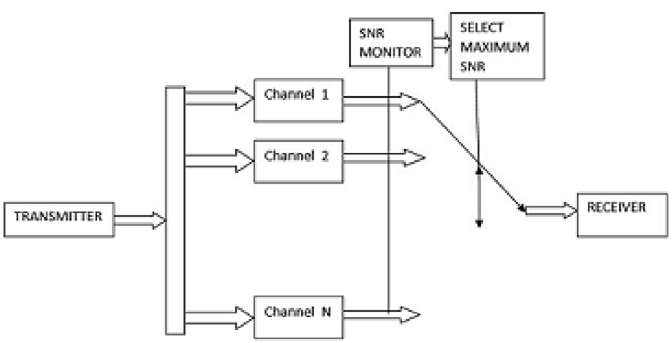

Fig 2. Selection Diversity

EQUAL GAIN COMBINING

In this type of combining technique, all the signals are weighted equally after coherent demodulation which removes the phase distortion. All the weighting parameters have their phase angle set opposite to those of their respective multipath branches and their magnitudes are set equal to some constant value. The coherently detected signals from all the M branches are simply added and applied to the decision device. As the receiver does not need to estimate the amplitude fading, the receiver design is not complex. Due to hardware limitations or physical separation of the diversity receivers, it is difficult to implement it practically. The performance of an equal-gain combiner is only marginally inferior to a maximal-ratio combiner and superior to a selection diversity combiner. Among the three linear combining techniques, maximal-ratio combining offers the best performance, followed by equal gain combining [8].

Various techniques are known to combine the signals from multiple diversity branches. In Equal Gain Combining, each signal branch weighted with the same factor, irrespective of the signal amplitude. However, co-phasing of all signal is needed to avoid signal cancellation.Thus, Equal Gain Combining is simpler to implement than Maximum Ratio Combining. The adaptively controller amplifiers / attenuators are not needed. Moreover, no channel amplitude estimation is needed [9-10]. Maximal Ratio Combining technique requires the weights to vary with the fading signals, the magnitude of which may fluctuate over several 10s of dB. The equal gain combiner sidesteps this problem by setting unit gain at each element. In the equal gain combiner, the weights and SNR are given by equations below:

$$\mathbf{w_n} = \mathbf{e^{j\angle h_n}}$$

$$\boldsymbol{\gamma} = \frac{\left[\sum_{n=0}^{N-1} |\mathbf{h_n}|\right]^2}{\mathbf{N\sigma^2}}$$

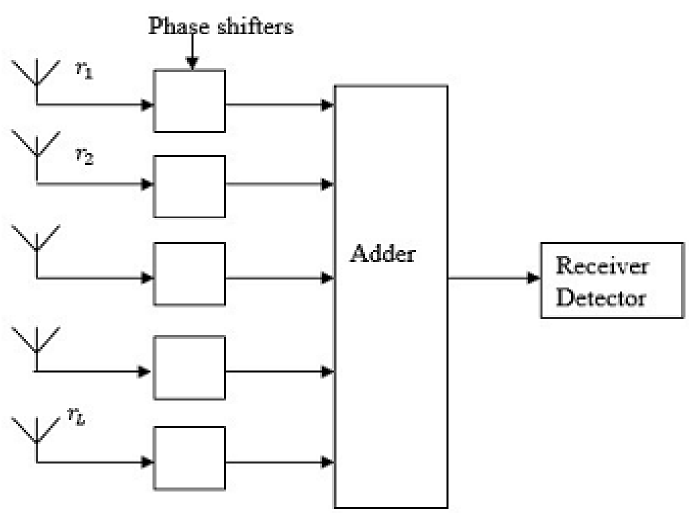

Figure: 3- branch Equal Gain Combining antenna diversity receiver (L = 5).

MAXIMAL RATIO COMBINING

It is considered to be the optimum technique of combining in which the diversity branches are weighted prior to summing them, each weight being proportional to the signal strength of the received branch. This technique assumes that the receiver is able to accurately estimate the amplitude fading and carrier-phase distortion for each diversity channel. The receiver coherently demodulates the received signal from each branch .After removing the phase distortion, the coherently detected signal is then weighted by the corresponding amplitude gain. The weighted received signals from all L branches are then summed together and applied to the decision device [11-15].
Branches with strong signal are further amplified, while weak signals are attenuated. Maximal Ratio Combining obtains the weights that maximizes the output SNR, i.e., it is optimal in terms of SNR. The output SNR is the sum of the SNR at each element.

$$\gamma = \sum_{n=0}^{N-1} \gamma_n$$

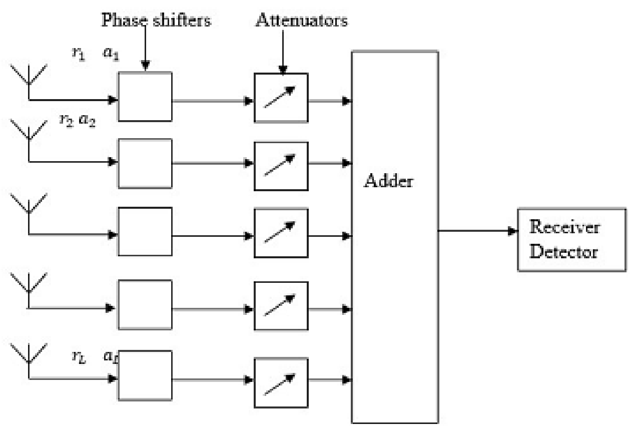

Figure: 4-branch antenna diversity receiver (L = 5). With MRC, the attenuation/amplification factor is proportional to the signal amplitude a_i = r_i for each channel i.

V. RESULTS AND DISCUSSION:

In the figures below, plot of the BER with the Eb/No for all the three techniques have been shown. This clearly shows that BER in case of MRC is much better than that of Equal Gain combining and selection diversity. The modulation technique chosen are QPSK i.e. Quadrature Phase Shift Keying and BPSK i.e. Binary Phase Shift Keying to represent the message signal. Results reveal that as the no. of receiver increases BER improves. Some numerical values of BER and SNR are presented in table 1, 2, 3 and 4 for analysis purpose. A table showing the methodology used to implement the different combining techniques and their performance analysis is given below:

Number of antennas	SNR (dB)	QPSK MODULATION			BPSK MODULATION		
		BER for MRC	BER for SC	BER for EGC	BER for MRC	BER for SC	BER for EGC
1	0	0.2193	0.2196	0.2193	0.1467	0.1464	0.1464
1	2	0.1625	0.1628	0.1625	0.1088	0.1084	0.1084
1	4	0.1158	0.1159	0.1160	0.0772	0.0774	0.0774
1	6	0.0793	0.0801	0.0791	0.0530	0.0533	0.0533
1	8	0.0532	0.0534	0.0535	0.0355	0.0356	0.0356
1	10	0.0349	0.0349	0.0350	0.0233	0.0233	0.0233

Table 1. BER for different combining techniques with 1 antenna

Number of antennas	SNR (dB)	QPSK MODULATION			BPSK MODULATION		
		BER for MRC	BER for SC	BER for EGC	BER for MRC	BER for SC	BER for EGC
2	0	0.0870	0.1229	0.1003	0.0579	0.0817	0.0666
2	2	0.0493	0.0741	0.0585	0.0326	0.0492	0.0390
2	4	0.0256	0.0411	0.0312	0.0169	0.0273	0.0206
2	6	0.0121	0.0209	0.0151	0.0081	0.0140	0.0101
2	8	0.0055	0.0099	0.0071	0.0038	0.0067	0.0047
2	10	0.0024	0.0044	0.0030	0.0015	0.0030	0.0021

Table 2. BER for different combining techniques with 2 antennas

Number of antennas	SNR (dB)	QPSK MODULATION			BPSK MODULATION		
		BER for MRC	BER for SC	BER for EGC	BER for MRC	BER for SC	BER for EGC
3	0	0.0374	0.0827	0.0496	0.0251	0.0552	0.0329
3	2	0.0161	0.0430	0.0228	0.0109	0.0287	0.0152
3	4	0.0060	0.0197	0.0091	0.0042	0.0131	0.0061
3	6	0.0021	0.0078	0.0032	0.0014	0.0051	0.0022
3	8	0.0006	0.0027	0.0011	0.0005	0.0019	0.0007
3	10	0.0002	0.0008	0.0004	0.0001	0.0006	0.0002

Table 3. BER for different combining techniques with 3 antennas

Number of antennas	SNR (dB)	QPSK MODULATION			BPSK MODULATIO		
		BER for MRC	BER for SC	BER for EGC	BER for MRC	BER for SC	BER EGC
4	0	0.0167	0.0619	0.0251	0.0110	0.0416	0.01
4	2	0.0056	0.0287	0.0091	0.0037	0.0192	0.00
4	4	0.0015	0.0112	0.0028	0.0010	0.0075	0.00
4	6	0.0004	0.0035	0.0007	0.0002	0.0024	0.00
4	8	0.0001	0.0010	0.0002	0.0000	0.0006	0.00
4	10	0.0000	0.0002	0.0000	0.0000	0.0002	0.00

Table 4. BER for different combining techniques with 4 antennas

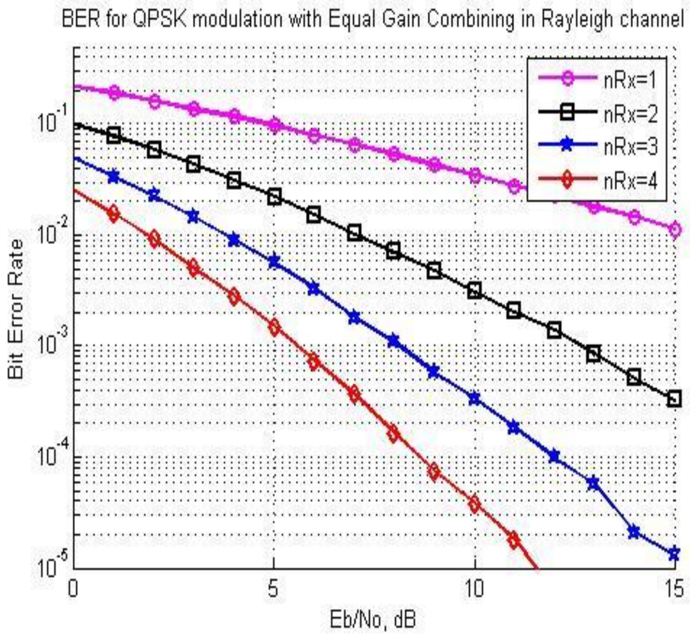

Fig 5. BER for QPSK with Equal Gain Combining in Rayleigh Channel

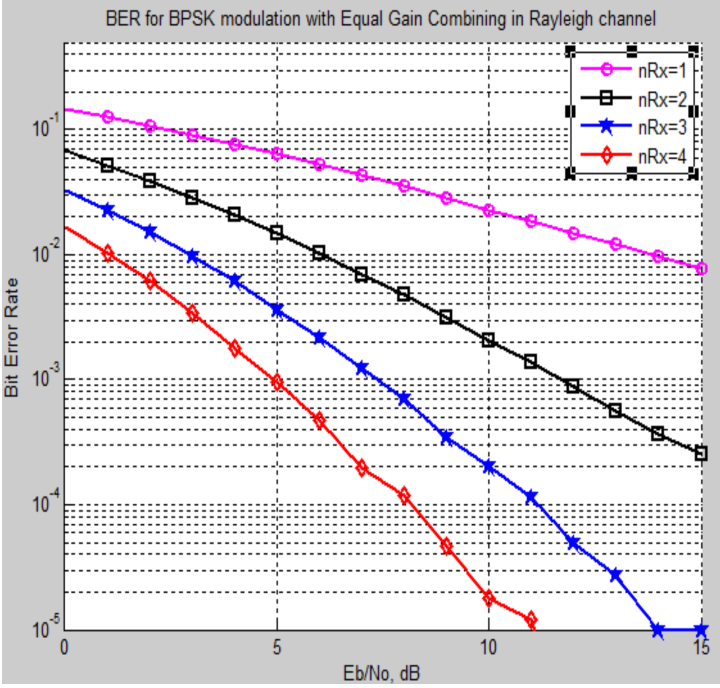

Fig 6. BER for BPSK with Equal Gain Combining in Rayleigh Channel

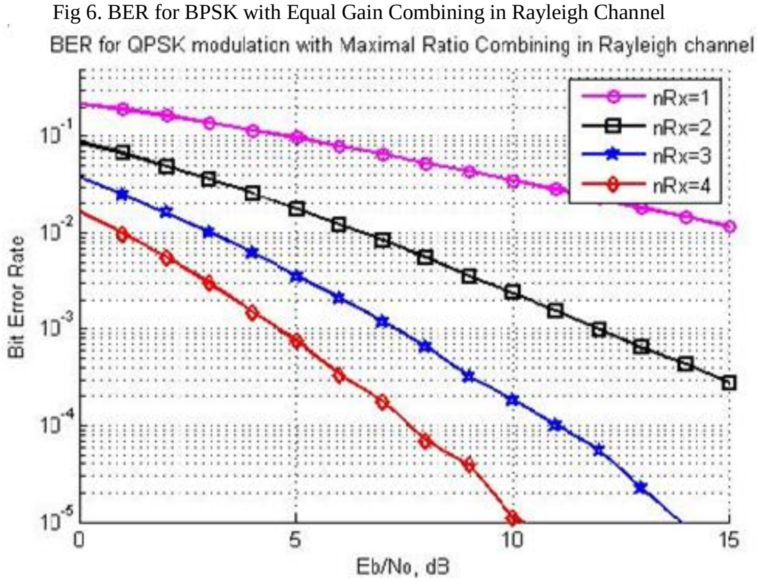

Fig 7. BER for QPSK with Maximal Ratio Combining in Rayleigh Channel

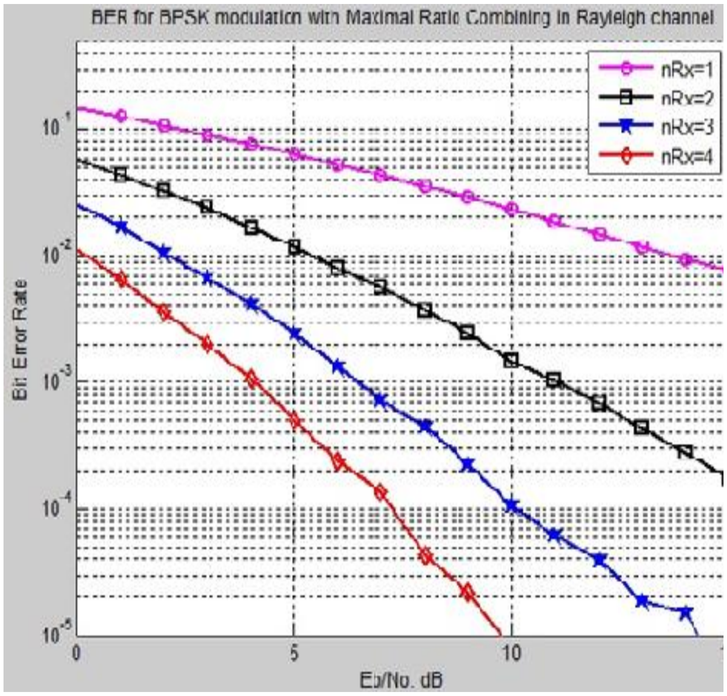

Fig 8. BER for BPSK with Maximal Ratio Combining in Rayleigh Channel

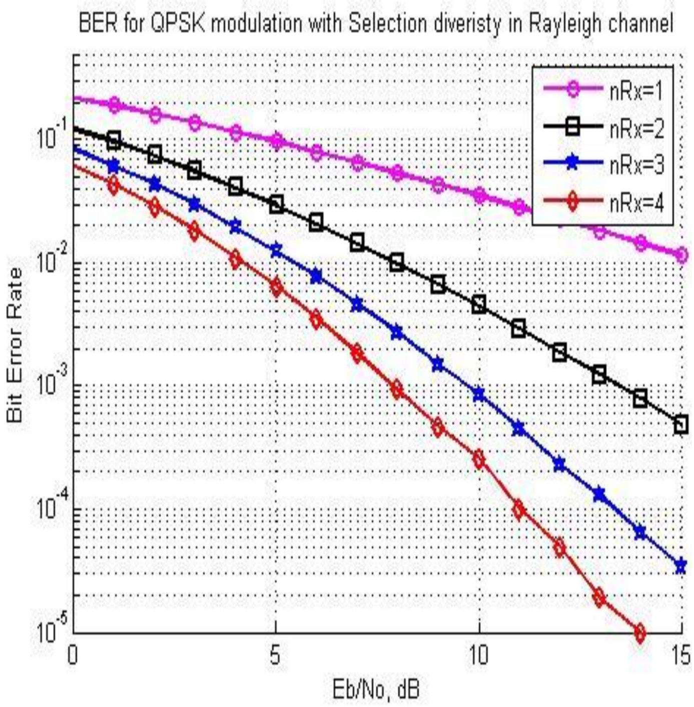

Fig 9. BER for QPSK with Selection Combining in Rayleigh Channel

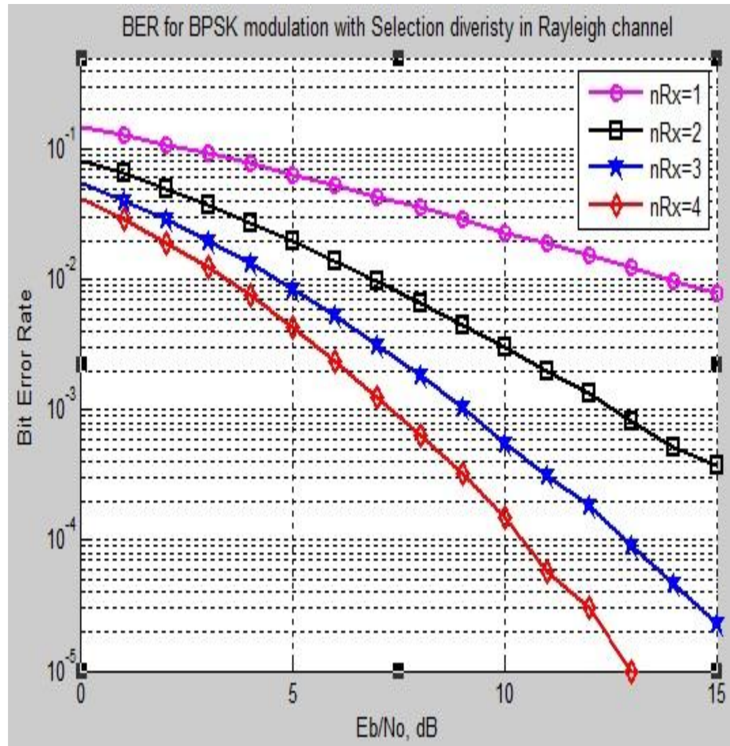

Fig 10. BER for BPSK with Selection Combining in Rayleigh Channel

From the above results it is observed that the BER for BPSK is less than QPSK for a given value of SNR and for specific combining technique. But data rate in case of QPSK is more than BPSK.This is the tradeoff between BER and data rate.

VI. CONCLUSION

As given in the literature, we have different diversity techniques for the receiver diversity i.e. EGC,MRC and SC. The results were taken for two different modulation schemes BPSK and QPSK in Rayleigh flat fading channel along with AWGN. In order to carry out the simulations,10^6random bits were generated as message signal.Data bits containing 1s and -1s were modulated using BPSK. Similarly,a QPSK modulated signal is generated using B1 and B2 data bits which is in the form of Q1+jQ2.Two random data bits B1 and B2 each of length N are formed from 10^6 bits. Where Q1=2B1-1 and Q2=2B2-1.

These modulated signals passed through Rayleigh channel. Signal gets degraded due to noise in the channel.It is observed that with different number of antennas, the bit error rate for maximal ratio combining has lesser value as compare to the equal gain combining and selection diversity. Therefore performance of maximal ratio combining is better than equal gain combining and selection diversity. The BER for BPSK is observed to be less than QPSK for a given value of SNR.The cause behind such an observation is the tradeoff between BER and data rate. To verify the results, BER v/s SNR graphs are plotted for each case.

REFERENCES

[1] Book, "MIMO-OFDM Wireless Communications with MATLAB" By Yong Soo Cho, Jaekwon K, Won Young Yang and Chung G. Kang.

[2] "Bit Error Rate Analysis in MIMO Channels With Fading and Interference "Invited By Jerez Department of Electronic Technology University of M´alaga 29071 M´alaga, Spain, 2010.

[3] Performance analysis for optimum transmission and comparison with maximal ratio transmission for MIMO systems with cochannel interference.

[4] Lin EURASIP Journal on Wireless Communications and Networking, 2011. By Robust Semi-Blind Estimation for Beam forming Based MIMO Wireless.

[5] Sam W. Ho,."Adaptive Modulation", (QPSK, QAM): IntelCommunications Group, 2004.

[6] He, R. and Xei, J. "BER Performance of M-QAM and MPSKNakagami fading channel with STTD," IEEE Inter. Sympo.On per. Indoor and mobile Radio communication, 2003.

[7] Amin, A. "Computation of Bit-Error Rate of Coherent andNon-Coherent Detection M-Ary PSK With Gray Code inBFWA Systems" International Journal of Advancementsin Computing Technology, Vol. 3, No. 1, 2011.

[8] Sarnin, S. S; Kadri, N.; Mozi, A.M.; Wahab, N.A.; Nairn,N.F., "Performance Analysis of BPSK and QPSK using errorcorrecting code through AWGN" International Conferenceon Networking and Information Technology, 2010.

[9] Kaul, S. K. "QPSK, OQPSK, CPM Probability Of Error forAWGN and Flat Fading Channels" Wireless CommunicationTechnologies Spring, 2005.

[10] Robust Semi-Blind Estimation for Beam forming Based MIMO Wireless Communication, Chandra R. Murthy1, Aditya K. Jagannatham2 and Bhaskar D. Rao3, publication in the IEEE "GLOBECOM" 2008 proceedings.,2008 IEEE.

[11] Book, "Space time codes and MIMO System" MohinderJankiraman.

[12] G. Brennan, "Linear diversity combining techniques," Proc. IRE, vol. 47, pp. 1075–1102,Jun. 1959.

[13] W. C. Jakes Jr., Microwave Mobile Communications. Piscataway, NJ: IEEE Press, 1994.

[14] Robust Semi-Blind Estimation for Beam forming Based MIMO Wireless Communication, Chandra R. Murthy1, Aditya K. Jagannatham2 and Bhaskar D. Rao3, publication in the IEEE "GLOBECOM" 2008 proceedings.,2008 IEEE.

[15] A Comprehensive Literature Survey on Antenna Selection in MIMO for Future Generation Wireless Systems, V. S. Hendre and M. Murug.

[16] B. Sklar, Digital Communications Fundamentals and Applications, Second Edition, Pearson Education, India, 2003.

[17] Performance Analysis of Wireless MIMO System by Using Alamouti's Scheme and Maximum Ratio Combining Technique by Muhammad Sana Ullah ,2011 Dept. of Electrical and Electronic Engineering.