Investigation in Terms of Bit Error Rate for Fixed and Mobile WiMAX under Different Modulation Schemes

Ankur Bindal, Deepak Kumar, Manish Kansal

***Abstract*— The aim of this paper is to analyze the bit error rate (BER) performance of WiMAX physical layer with the implementation of different modulation formats, for fixed and Mobile WiMAX. The Simulation also includes the altering multipath fading (Raleigh and Rician) channels and their parameters. A segment of synthetic data is used for the analysis. The main part of this simulation is the inclusion of RRC filters at transmitter and receiver as a matched filter. In addition to this , channel estimation is computed using a popular technique known as interpolation. Computer simulation results based on BER and bit energy to noise ratio (Eb/No) demonstrate that the performance.**

***Index Terms*— WiMAX, Interpolation, RRC filters.**

I INTRODUCTION

In last decade, for high data rate applications orthogonal frequency division multiplexing is among the most important preference. In this technique, instead of using single wide band carriers a number of narrow band carriers are used and it is also effective to deal with multipath fading channel. OFDM is used for reducing the Intersymbol Interference (ISI) by avoiding multipath in frequency selective channels. WIMAX is short form of e Worldwide Interoperability for Microwave Access. WiMAX is mainly used for high bandwidth application. For the implementation of the WiMAX model, simulation model used is MATLAB(R2011a). Based on the various modulation techniques in this paper we are investigating the performance of Bit Error Rate in correspondence to the bit energy to noise ratio [2]. To enhance the performance of the system here sub allocation of carriers along with raised cosine filter. As a result, the error rate will be reduced.

II WIMAX SIMULATION MODEL

To implement the OFDM transmission scheme, the system is divided into three sections –Transmitter, Channel and Receiver. In the, binary input data sequence is take place in the transmitter. Forward Error-Correction Coding (FEC)and interleaving is done to give frequency diversity. The series is encoded by a convolutional encoder. Then Interleaving is applied to randomize the occurrence of bit errors prior to increase performance.
After interleaving, the binary values are converted to symbol values, on which digital modulation scheme is applied[1]. Previously, multi-carrier systems were implemented through the use of separate local oscillator. This was both inefficient and costly. With the start of cheap powerful processors, the sub-carriers currently be implemented by the FFT which keep tones to orthogonal with each other the symbol is modulated onto sub carriers by apply the Inverse Fast Fourier Transform (IFFT). Output is converted to serial and a cyclic extension is added to make the system robust to multipath propagation.
In channel, additive white Gaussian noise characteristics are taken. The receiver performs the reverse operations of the transmitter. After removing the cyclic extension, the signal can be applied to a Fast Fourier transform to recover the modulated values of all subcarriers. The modulated values are then demapped into binary values, and finally deinterleaving and Viterbi decoder decodes the information bits[4].

III SUBCARRIER ALLOCATION

WiMAX define three types of subcarriers: null subcarriers, data and pilot. The mapped data symbols from the very last step are arranged to be a matrix where its rows number is equal to the number of data subcarriers (S). Other then pilot, data subcarriers and NULL sub-carriers is inserted in the input signal.
Basically one OFDM symbol consists of the S_{data} PSK or QAM symbols, S_{pilots} and S_{guard} empty symbol. The total amount of sub-carriers is calculated by the number of points required to perform IFFT. The data sub-carriers are weighed down by the data symbols modulated.

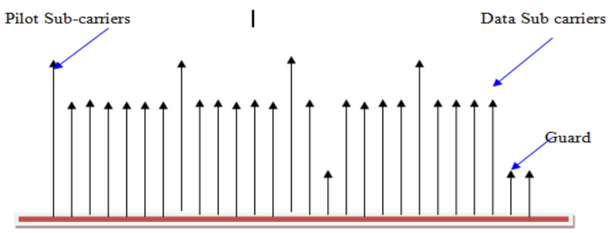


Fig. 1 Sub-carrier allocation

Pilot symbols can be used to execute frequency offset compensation at the receiver. Furthermore, they can be used for channel assessment in fast time-varying channels. Pilot symbols give out specific subcarriers in all OFDM data symbols. These pilots are obtained by a pseudo-random binary sequence (PRBS) generator that is based on the polynomial $x^{11}+x^{9}+1$[5].

IV RRC FILTERS

A criterion that ensures non-interference specifies the shape of the pulses to be such that its amplitude decays rapidly outside the pulse interval. A widely used filter for this purpose is the known raised cosine filter, which satisfies

ISSN: 2278 – 909X

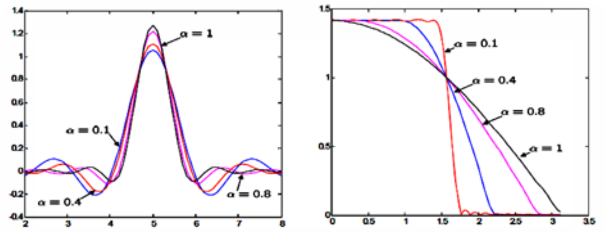
Nyquist's first criterion.The RRC frequency response of a raised cosine filter is specified by the following function:-

$$H_{RRC}(f) = \begin{cases} 1 & |f| \le f_N(1-\alpha) \\ \sqrt{\cos\left(\frac{\pi T_{sym}}{2\alpha}\left(|f| - \frac{1-\alpha}{2T_{sym}}\right)\right)} & f_N(1-\alpha) \le |f| \le f_N(1+\alpha) \\ 0 & |f| \ge f_N(1-\alpha) \end{cases} \quad (1)$$

f_N is the Nyquist frequency which is equal to $\frac{1}{2T_{sym}}$

, where T_{sym} is the modulation symbol duration.

α is the roff- off factor which defines the width of the central frequencies and also determine the sharpness of the frequency response. The range for the roff- off factor is decided by the standards is between 0 to1.



(a) Impulse response $h_{rrc}(t)$. (b) Frequency response $H_{rrc}(f)$.

Fig. 2 Frequency and Impulse response graph

From the above frequency response,

When $\alpha = 0$, the response is in the rectangular shapeis having a decay of edge in the slowest rate and offering narrowest bandwidth. However, if $\alpha = 1$, the frequency response is in round shape and the decay of edge rapid but requires large bandwidth; by this we can conclude that the smaller the roll–off factor better the performance will be in term of bandwidth.
In our simulation, we have to split the filtering equally among both the transmitter's filter and receiver's filter. For this we are using a pair of square root raised cosine filters to achieve pulse shaping and matched filtering at the transmitter and receiver, respectively without introducing inter-symbol interference (ISI). In theory, the combination of two square-root raised cosine filters is equivalent to a single normal raised cosine filter. By this method, we split the filtering between transmitter and receiver.

Property	**Value**
Order	**40**
Up sampling factor	**2**
Roll off factor α	**0.25**
Group delay	**10**

Table 1 FIR root raised cosine filter

If the sampling frequency of the input signal is F/2. The sampling frequency of the filter is F_s, then the up sampling factor is Ff /Fs. Before filtering, the initial parameter of the filter such as, filter order, up sampling factor, roll off factor and group delay must be given. The group delay of the filter can be calculated by (filter order/(2*Ff)).

V OFDM MODUALTION

Mobile radio channels introduce severe multipath propagation due to multiple scattering from objects in the surrounding area of the mobile. Also the gesture of the mobile unit introduces a Doppler shift which causes a broadening of the signal spectrum.
The multipath channel can also be frequency selective in which case the fading envelope of the received signal at one frequency might not be correlated with the envelope at another frequency.
To obtain a channel which has no ISI it is necessary that the symbol time T_s should be more or greater than the channel delay spread time τ and if the symbol time approaches or falls below the channel delay spread time then the BER becomes intolerable and the system is unbearable.
The key benefit is that the parallel transmission enlarges the symbol time by modulating the symbols into narrow sub-channels. This increase in symbol time makes it more vigorous to the channel delay spread effects.

VI DOPPLER SPREAD IN CHANNEL

Due to the multipath propagation of radio waves, multiple copies of the same signal are received at the receiver end. If the user is moving with some velocity (speed), there is a shift of frequencies in each of these received signals [5]. This process is known as Doppler shift.

$$f_d = f_c \frac{v}{c} \cos\alpha \quad (2)$$

Where, f_d be the Doppler shift frequency, v is the velocity of moving object,
c be speed of light and α is an angle with respect to reference point.

Where, f_d be the Doppler shift frequency,
f_c is carrier frequency (2.500e9 Hz)
v is the velocity of moving object,
c be speed of light (3e8 m /s) and
α is an angle with respect to reference point.
For velocity =30 Km/h, the Doppler frequency will be:-
$f_d = 144\ Hz$

For velocity =60 Km/h , the Doppler frequency will be :-
$f_d = 360\ Hz$
For velocity =100 Km/h , the Doppler frequency will be :-
$f_d = 555\ Hz$

ISSN: 2278 – 909X

VIII INTERPOLATION

The data symbols are estimated after the estimation of the pilot locations for this interpolation is used. There are many kinds of interpolations but here in this simulation one dimensional spline cubic interpolation is used. The spline cubic interpolation gives a smooth and continuous polynomials for a given data point. The spline cubic interpolation in MATLAB is given by function *interp* where 'spline' is used for smooth interpolation[3].

After this equalization is performed in which equalized by a complex division of received signal and the estimated signal. By this process the effect of multipath fading is reduced very much and output response is manipulated.

VII SIMULATION RESULTS

In this simulation work , Bit error rate is plotted against bit energy to noise ratio for various models.

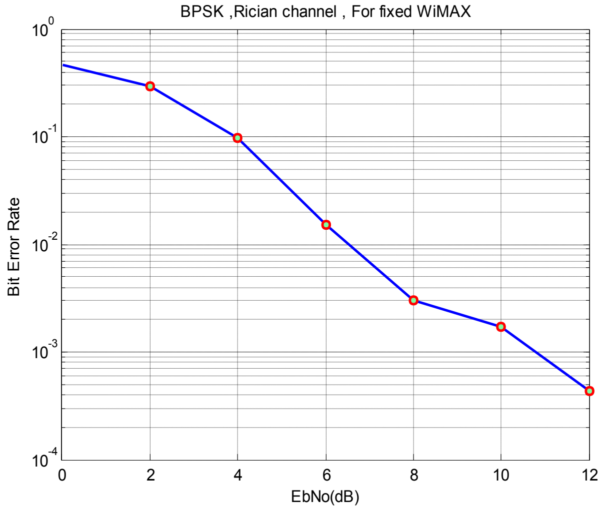


Figure3 BER Vs Eb/No Plot for Rician channelin fixed WiMAX BPSK

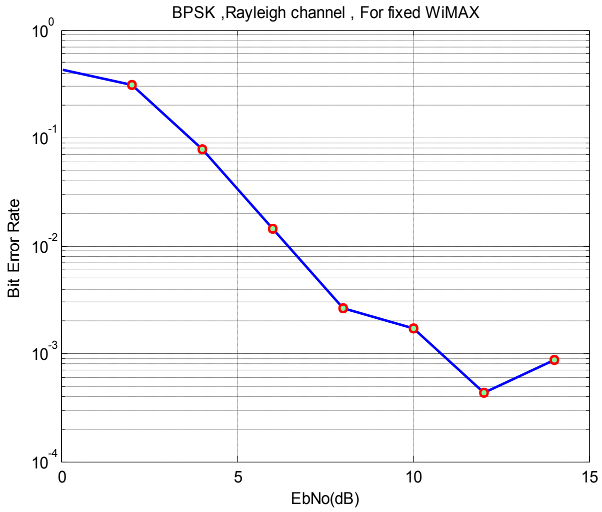


Figure 4 BER Vs Eb/No Plot for Rician channel in fixed WiMAX BPSK

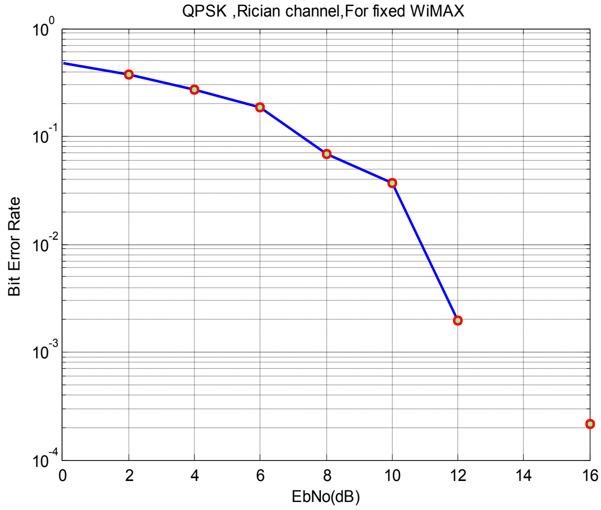


Figure 5 BER Vs Eb/No Plot for Rician channel in fixed WiMAX QPSK

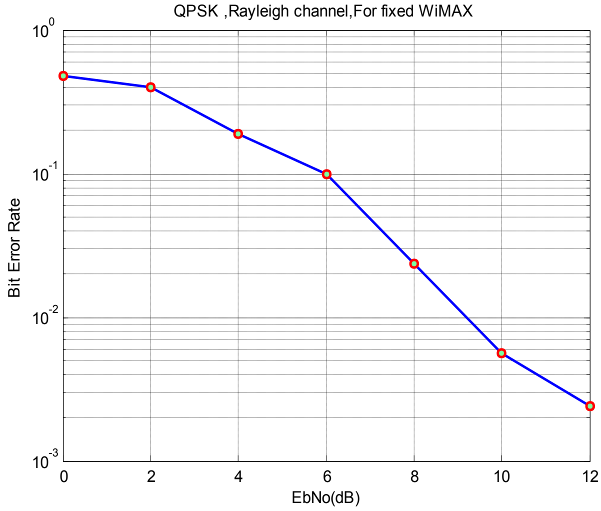


Figure 6 BER Vs Eb/No Plot for Rayleigh channel in fixed WiMAX QPSK

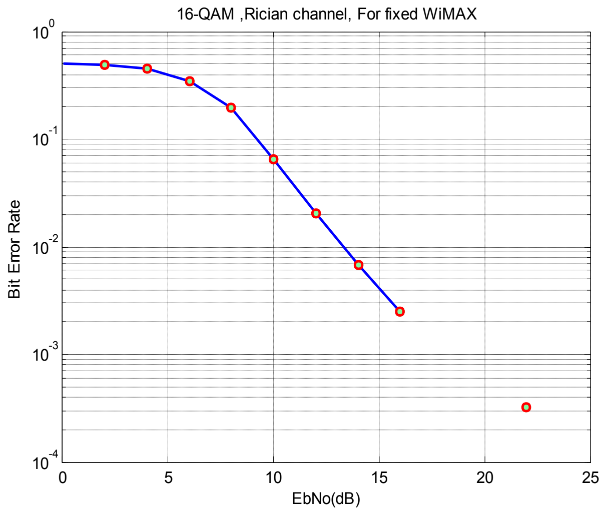


Figure 7 BER Vs Eb/No Plot for Rician channel in fixed WiMAX 16-QAM

ISSN: 2278 – 909X

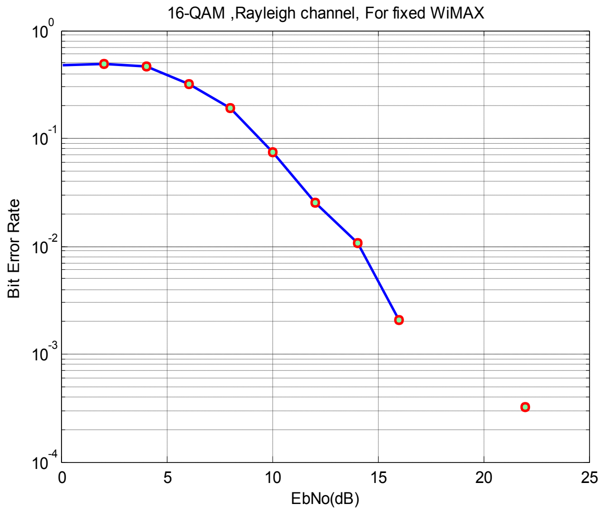


Figure 8 BER Vs Eb/No Plot for Rayleigh channel in fixed WiMAX 16-QAM

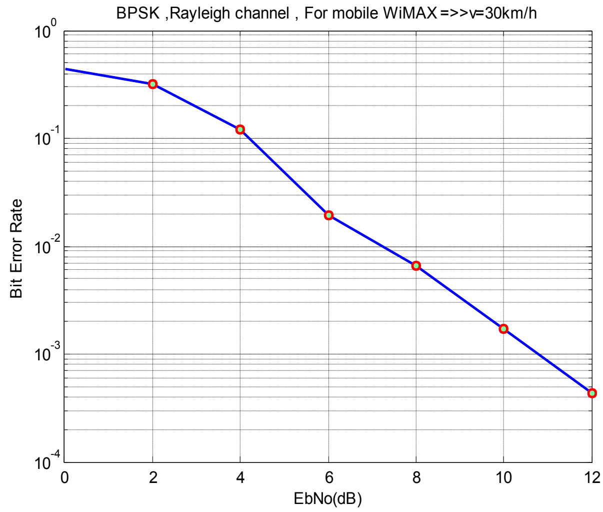


Figure 11 BER Vs Eb/No Plot for mobile WiMAX BPSK (V=30 km/h)

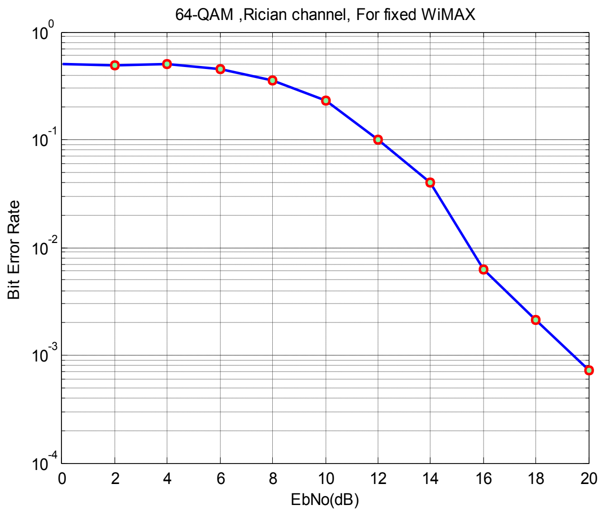


Figure 9 BER Vs Eb/No Plot for Rician channel in fixed WiMAX 64-QAM

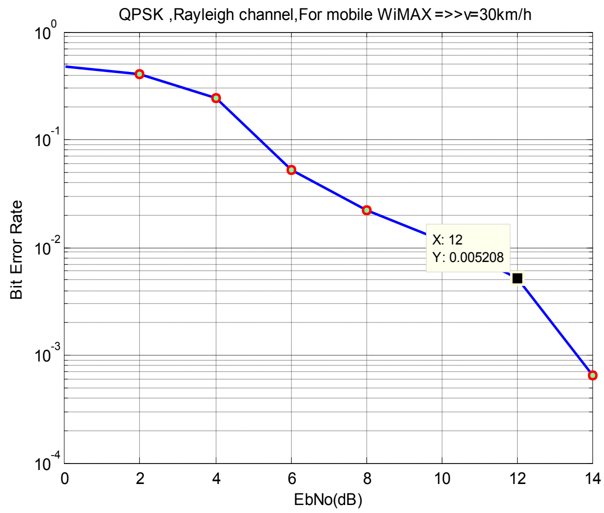


Figure 12 BER Vs Eb/No Plot for mobile WiMAX QPSK (V=30 km/h)

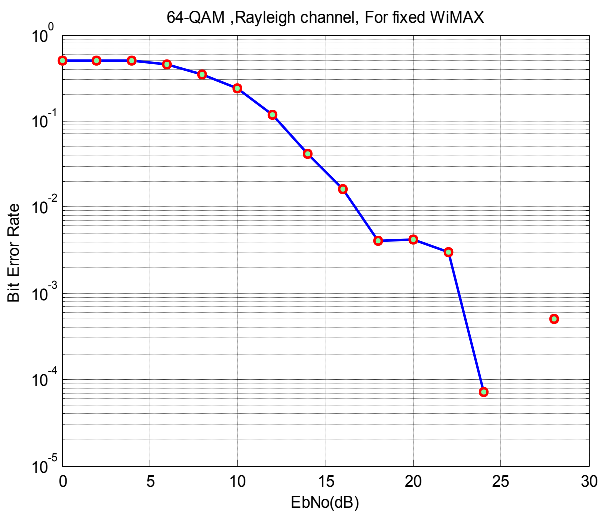


Figure 10 BER Vs Eb/No Plot for Rayleigh channel in fixed WiMAX 64-QAM

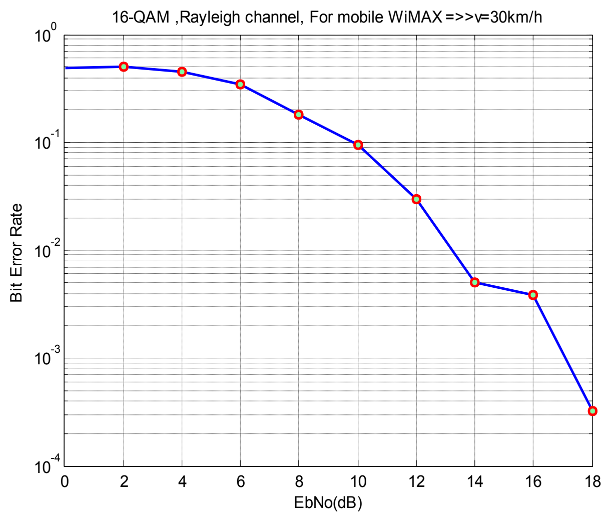


Figure 13 BER Vs Eb/No Plot for mobile WiMAX 16-QAM (V=30 km/h)

ISSN: 2278 – 909X

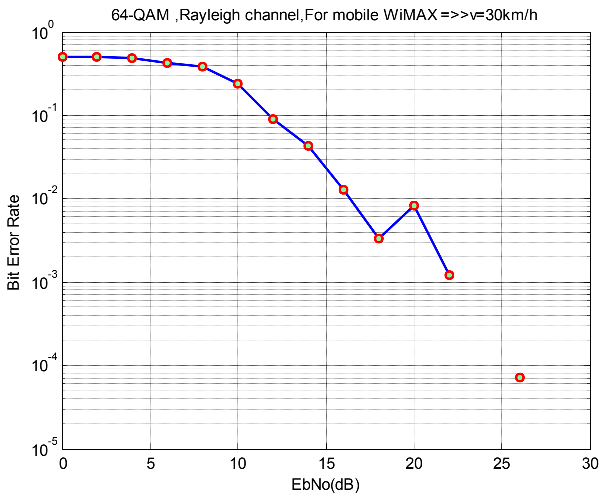


Figure 14 BER Vs Eb/No Plot for mobile WiMAX 64-QAM (V=30 km/h)

BER CALUCATION

On the basis of the BER Vs Eb/No plot in this simulation we have estimated the tables.

For fixed WiMAX (Rician Channel)				
Eb /No	Bit Error Rate(BER)			
	BPSK	QPSK	16-QAM	64-QAM
2	0.2934	0.3776	0.4858	0.4906
4	0.09635	0.273	0.4551	0.4991
6	0.01519	0.1855	0.3432	0.4535
8	0.003038	0.06923	0.1977	0.3566
10	0.001736	0.03733	0.06489	0.2316

Table 2 Comparison among BER Vs Eb/No for fixed WiMAX in Rician Channel

For fixed WiMAX (Rayleigh channel)				
Eb/No	Bit Error Rate(BER)			
	BPSK	QPSK	16-QAM	64-QAM
2	0.3069	0.3963	0.4844	0.5022
4	0.07813	0.1908	0.4699	0.5007
6	0.01432	0.09939	0.3211	0.4468
8	0.002604	0.02365	0.1912	0.3464
10	0.001736	0.005642	0.074	0.2386

Table 3 Comparison among BER Vs Eb/No for fixed WiMAX in Rayleigh Channel

For mobile WiMAX (V = 30 km/h)				
Eb /No	Bit Error Rate(BER)			
	BPSK	QPSK	16-QAM	64-QAM
2	0.3155	0.4102	0.5052	0.5
4	0.1207	0.2444	0.4461	0.485
6	0.01953	0.05252	0.3468	0.4308
8	0.00651	0.02235	0.1797	0.3797
10	0.001736	0.01172	0.09408	0.2392

Table 4 Comparison among BER Vs Eb/No for fixed WiMAX in Rician Channel

CONCLUSION

In OFDM system with IEEE 802.16 standard implementation for Fixed and mobile WiMAX, the various modulation techniques are tested for different channel conditions. The BER performance of system through broadband WiMAX-PHY layer based wireless communication system adopting the RRC Transreceiver filter and Sub allocation of carriers along with different digital modulation schemes is evaluated. A range of system performance highlights the impact of digital modulations. The most important conclusions are given below:

- In Fixed WiMAX, when the channel is Rician i.e. Line of Sight transmission. In this case, for Eb/No= 2db, the BER is 0.2934 for BPSK where as in case of 64-QAM is 0.4906.
- In Fixed WiMAX, for the Rayleigh channel which is Non line of light transmission channel. In this case, for Eb/No= 2db, the BER is 0.3069 for BPSK where as in case of 64-QAM is 0.5022.
- In Mobile WiMAX at vehicular speed 30 km/h, for the Rayleigh channel. When Eb/No =2db then BER of BPSK is 0.3155 where as BER for 64-QAM is 0.5.

From the above three main points, we can conclude the performance factors in terms of low BER, High data rate and efficient channel.
Lowest Bit Error Rate is of the Fixed WiMAX
for the channels which have poor conditions BPSK Modulation is the best techniques. In case of high data rate only the higher level modulation (64- QAM) can provide that rate . when the channel is came into consideration Rician channel is having the efficient utilization of the signal.

REFERENCES

[1] Vikas K. Sukhjit Singh;"**WiMAX Physical Layer Simulator Using Different Modulation Schemes**" ; *IJCER* , Vol. 3 Issue. 2, Issn 2250-3005, 2013.

[2] Hardeep Kaur, M L Singh; "**Bit Error Rate Evaluation of IEEE 802.16 (WiMAX) in OFDM System**" ; *IJCA*-0975 – 8887 , Volume 40– No.12 ,2013.

[3] Yongxue Wang; "**Study of Interpolation Algorithm for WIMAX-OFDM System**" ; *Journal of Information & Computational Science* 9: 13 (2012) 3673–3681, 2012.

[4] Md Ash. Islam,Riaz Uddin, Md.Zahid; "**Performance Evaluation of Wimax Physical Layer under Adaptive Modulation Techniques and Communication Channels**"; *University of Rajshahi, Rajshahi, Bangladesh;IJCSIS*-vol.5,No, 2009.

ISSN: 2278 – 909X

[5]Theodore S. Rappaport; "**Wireless Communications: Principles & Practice**", *2nd ed., Prentice Hall*,2007.
[6]Israel Koffman, Vincentzio Roman; "**Broadband Wireless Access Solutions Based on OFDM Access in IEEE 802.16**", *IEEE Communication Magazine*,2002.
[7] J. Mountassir, M. Kovaci et.al ; " **A physical layer simulator for WiMAX in Rayleigh fading channel**",*6th IEEE International (SACI)*, pp. 281-284,2011.

Ankur Bindal received his B.Tech. degree in Electronics and communication Engineering from Jind Institute of Engineering and Technology, Jind, Haryana in 2011 and pursuing M.Tech in ECE from Panchkula Engineering College, Panchkula, Haryana. Presently He is working as lecturer in Department of Electronics and Communication Engineering in M.M.E.C., M.M.U. Mullana (Ambala).

Deepak Kumar received his B.Tech. degree in Electronics and communication Engineering and M.Tech in ECE from PEC. Presently He is working as Assistant Professor in Department of Electronics and Communication Engineering in P.E.C., Mouli(Panchkula).

Manish Kansal received his B.Tech. degree in Electronics and communication Engineering and M.Tech in ECE from M.M.E.C., M.M.U. Mullana. Presently He is working as Head of ECE department and Assistant Professor in Department of Electronics and Communication Engineering in P.E.C., Mouli(Panchkula).

ISSN: 2278 – 909X