PERFORMANCE EVALUATION OF MC-CDMA SYSTEM USING DELTA MODULATION IN ULTRA WIDE BAND CHANNEL

Akhil Vitthalrao Gite, Athar Ravish Khan, Sanjay M. Gulhane

Department of Electronics & Telecommunication
Jawaharlal Darda Institute of Engineering and Technology Yavatmal
Maharashtra State, INDIA
akhilgite@gmail.com, mr.atharravishkhan@rediffmail.com

Abstract: **The multi carrier technique looks promising as a 4G standard. Need of next generation is low power and high data rate, to increase data rate it is required to increase the bandwidth, at large bandwidth the channel becomes more frequency selective and more robust, channel model proposed by study group IEEE 802.15.SG3a is one of the example of high frequency UWB channel model. This paper evaluates the bit error rate (BER) performance of multi-carrier code division multiple access (MC-CDMA) over high frequency multi-path channel model of study group IEEE 802.15.SG3a. We investigated the BER performance, with different modulation schemes like binary phase shift key (BPSK) and delta modulation (DM), over IEEE channel using different number of carrier in MC-CDMA system and compare the performance with theoretical BER values over AWGN and Rayleigh channel.BER curve shows that MC-CDMA system can withstand in IEEE channel and DM is more suitable modulation scheme.**

Keywords: **MC-CDMA, IEEE UWB channel, Delta Modulation, BER.**

I. INTRODUCTION

Wireless broadband communications is a rapidly growing industry. In the discussions about 3G systems in the 1990s, there were two candidates, the CDMA scheme, which was adopted in the one generation and the OFDM-based multiple access scheme called band division multiple access (BDMA) [22]. CDMA was finally adopted as the standard. Combination of code division multiple access (CDMA) and orthogonal frequency division multiplexing (OFDM) such as MC-CDMA are shaping the future of 4G wireless systems. However, research efforts in improving, MC-CDMA receiver performance, have received limited attention and there is a need for innovative receiver designs for next generation MC-CDMA. The OFDM scheme is insensitive to frequency selective fading but it has severe disadvantages such as difficulty in subcarrier synchronization and sensitivity to frequency offset and nonlinear amplification; on the other hand, the CDMA scheme has robustness against frequency selective fading. By combining OFDM with CDMA, we can have synergistic effects, such as enhancement of robustness against frequency selective fading and high scalability in possible data transmission rate. Multicarrier techniques can combat hostile frequency selective fading encountered in mobile communications. The robustness against frequency selective fading is very attractive, especially for high-speed data transmission. OFDM scheme has been well matured through research and development for high-rate wireless LANs and terrestrial digital video broadcasting. We have developed a lot of know-how on OFDM. So far, a lot of reports have been dedicated for the BER analysis of MC-CDMA system in frequency-selective Rayleigh fading channels and in AWGN channel. In general, fading characteristics among subcarriers are highly correlated, and the subcarrier correlation is uniquely determined by the multipath delay profile of the channel. Therefore, it is required to evaluate BER performance of MC-CDMA system in SV channel model so that it can sustain in 4G system.

II. MC-CDMA SYSTEM STRUCTURE

The basic transmitter structure of MC-CDMA scheme is similar to that of OFDM scheme used in digital audio broadcasting (DAB) system. The main difference is that the MC-CDMA scheme transmits the same symbol in parallel through a lot of subcarriers whereas the OFDM scheme transmits different symbols. Fig.1 shows the MC-CDMA proposed system for the single user with BPSK format and DM format [8]. The input information sequence is first converted into parallel data sequences and then each Serial/Parallel converter output is multiplied with the spreading code with

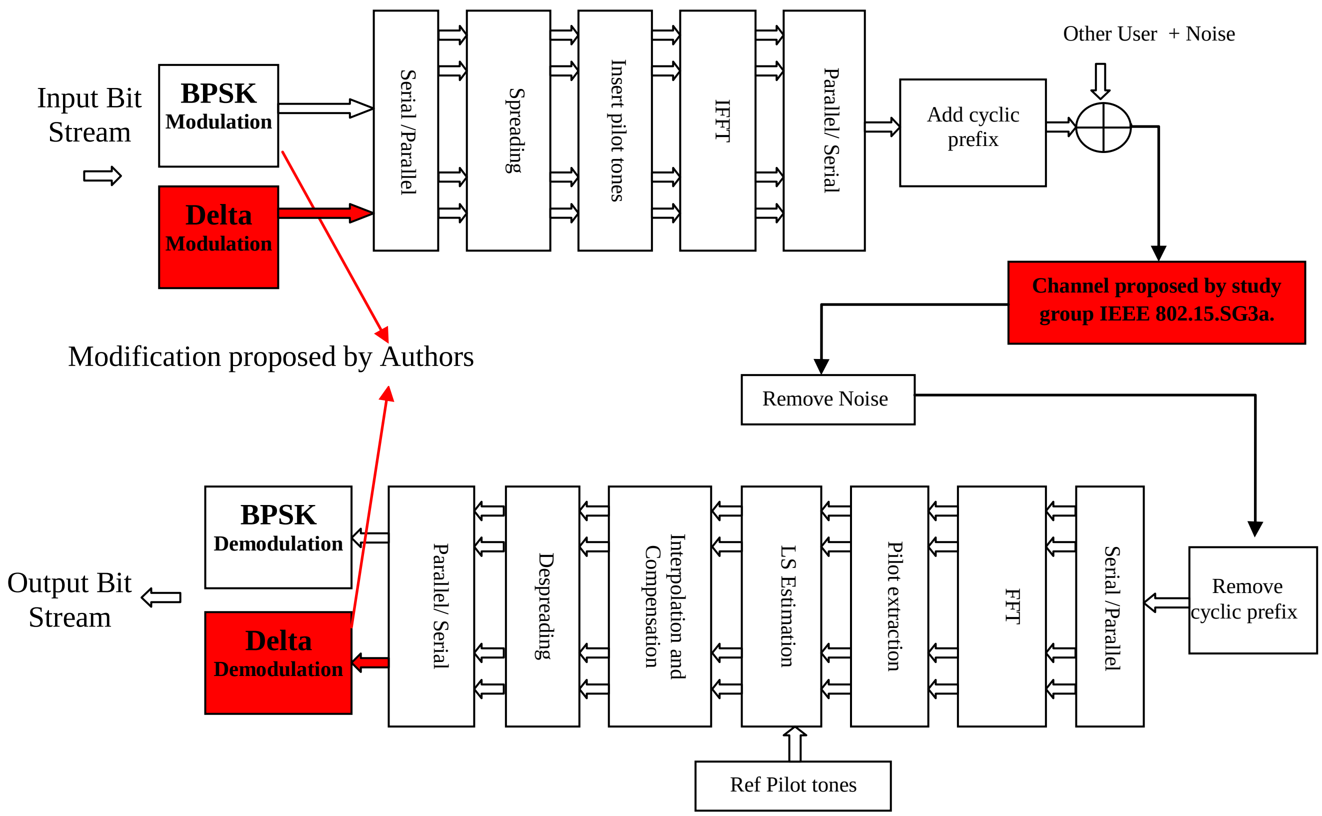

Figure.1 Proposed MC-CDMA system

length. All the data in total (corresponding to the total number of subcarriers) are modulated in baseband by the Inverse Fast Fourier transform (IFFT) and converted back into serial data. The cyclic prefix is inserted between symbols to avoid inter symbol interference (ISI) caused by multipath fading, and finally the signal is transmitted after radio frequency (RF) up conversion [7]. MC-CDMA receiver requires coherent detection for successful dispreading operation. This could give us an impression that the structure of MC-CDMA receiver is very complicated, as compared with that of normal OFDM receiver which employs differential detection to avoid complicated subcarrier recovery. Fig.1 shows the MC-CDMA receiver for the single user. After removal of noise, cyclic prefix and down conversion, the subcarrier components corresponding to the received data is first coherently detected with Fast Fourier Transform (FFT)and then multiplied with the gain to combine the energy of the received signal scattered in the frequency domain. We use Least Square estimation method using extracted Pilot. Output bit stream is estimated by dispreading and demodulation of extracted data.

III. Proposed Modulate Scheme

PCM and Shift keying are powerful, but quite complex coders and decoders are required. An increase in resolution also requires a higher number of bits per sample. Standard digital modulation systems have no memory each sample value is separately encoded into a series of binary digits. An alternative, which overcomes some limitations of PCM and Shift keying is to use past information in the encoding process. One way of doing this is to perform source coding using delta modulation:

The signal is first quantized into discrete levels, but the size of the step between adjacent samples is kept constant. The signal may therefore only make a transition from one level to an adjacent one. Once the quantization operation is performed, transmission of the signal can be achieved by sending a zero for a negative transition, and a one for a positive transition. Note that this means that the quantized signal must change at each sampling point. For the case shown in Fig.2, the transmitted bit train would be 111100010111110. The demodulator for a delta modulated signal is simply a staircase generator. If a one is received, the staircase increments positively, and if a zero is received, negatively. This is usually followed by a low pass filter. The key to using delta modulation is to make the right choice of step size and sampling period an incorrect selection will generates granular noise or

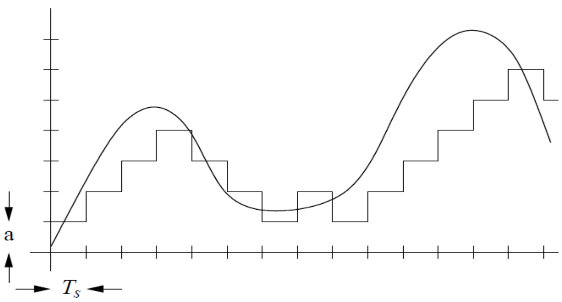

Figure.2 Example of Delta Modulated Signal

slope overloading. When the step is too small slope overloading will occurs and when the step is too large granular noise will occurs. We extracted Delta Modulated signal from MC-CDMA system simulation and selected the optimum value for proper modulation as shown in Fig.4,5,6.

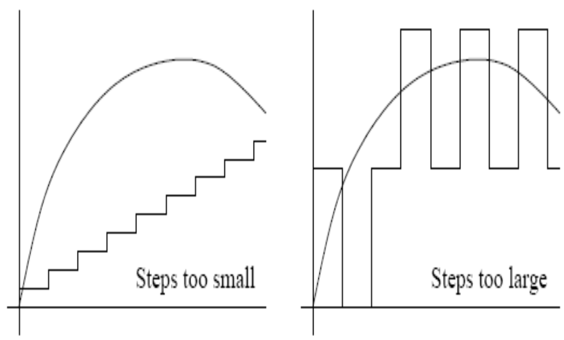

Figure.3 Selection of Step size for delta modulation

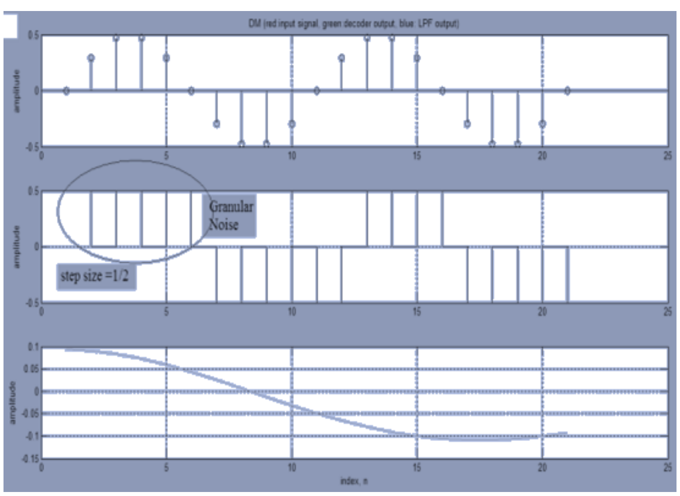

Figure.4 Selection of step size 1/2 for delta modulation

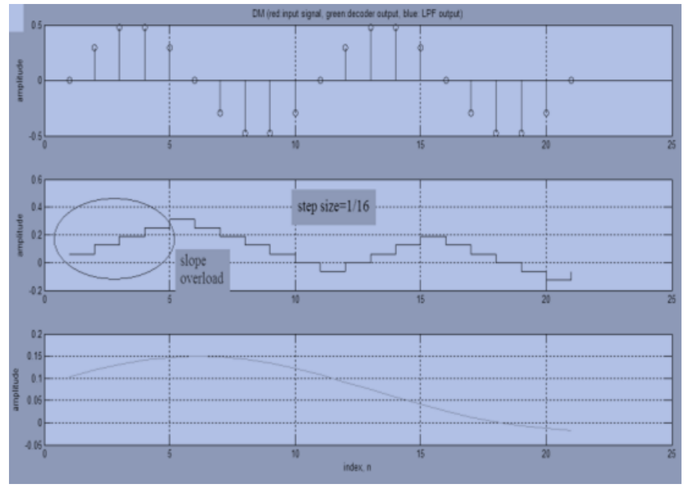

Figure.5 Selection of step size 1/16 for delta modulation

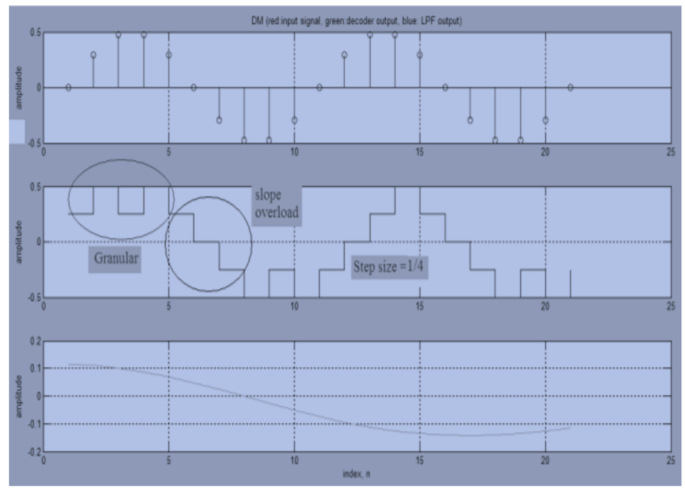

Figure.6 Selection of step size 1/4 for delta modulation

IV. IEEE UWB CHANNEL MODELING

In July 2003, the Channel-Modeling sub-commettee of study group IEEE 802.15.SGa published the final report regarding the UWB indoor multi-path channel model (IEEE 802.15.SG3a, 2003). IEEE channel-Modeling sub-commettee finally converged to a model, based on the cluster approch proposed by Saleh and Valenzuela in

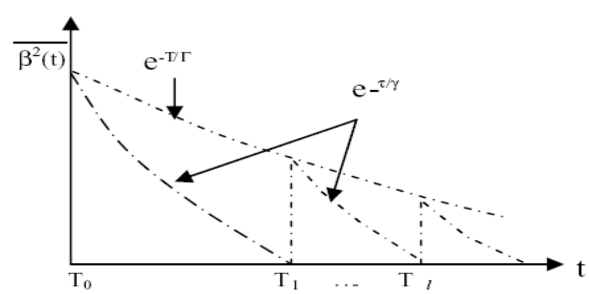

Figure 7.Schematic representation of UWB channel Model

1987 [2]. The S-V model is based on the observation that usually multipath contributions generated by the same pulse arrive at the receiver grouped into cluster. The time of arrival of cluster is modeled as a poission arival process with rate Λ.

$$p(T_n|T_{n-1}) = \Lambda e^{-\Lambda(T_n - T_{n-1})} \quad (1)$$

Where T_n and T_{n-1} are the time of arrival of the n-th and (n-1)-th cluster respectively. Within each cluster, subsequent multipath contributions also arrive according to apposition process with rate λ

$$p(\tau_n|\tau_{(n-1)k}) = \lambda e^{-\lambda(\tau_n - \tau_{n-1})} \quad (2)$$

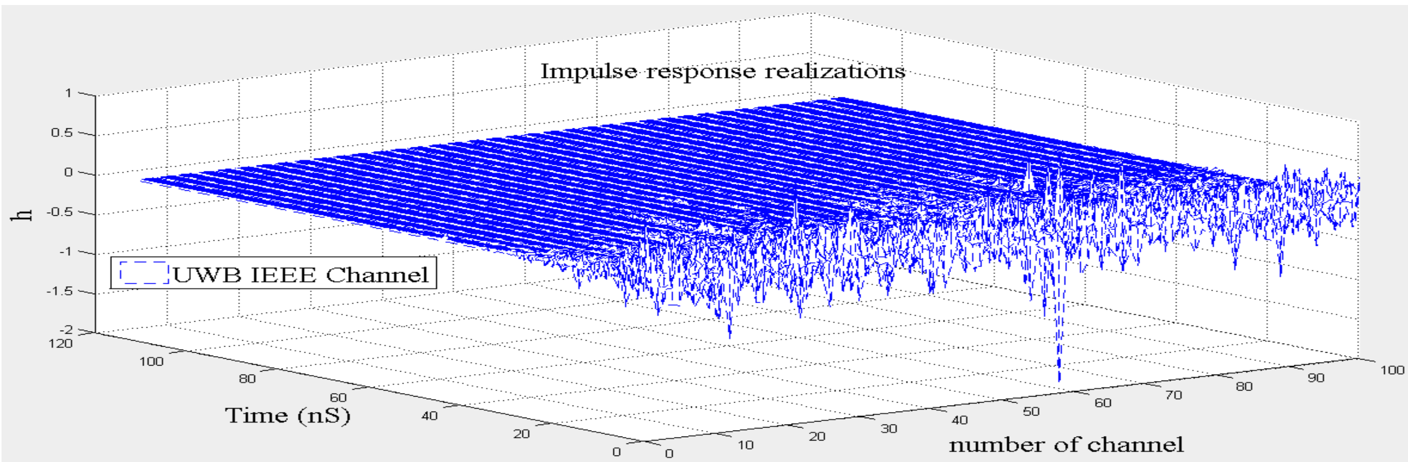

Figure 8 Impulse response of IEEE UWB channel

The channel impulse response of the IEEE model can be express as

$$h(t) = X \sum_{n=1}^{N} \sum_{k=1}^{K(n)} \alpha_{nk}\, \delta(t - T_n - \tau_{nk}) \quad (3)$$

Where X is a lognormal distributed random variable representing the magnitude of channel gain.

$$X = 10^{\frac{g}{20}} \quad (4)$$

Where g is Gaussian random variable with mean g_0 and variance σ_g^2, N is the observed number of clusters, K(n) is the received number of multipath in the n^{th} cluster, α_{nk} is coefficients of the k^{th} path in the n^{th} cluster. T_n is the arrival time of the n^{th} cluster, τ_{nk} is the k^{th} path delay in the n^{th} cluster. The channel coefficient α_{nk} can be define as follows:

$$\alpha_{nk} = p_{nk}\beta_{nk} \quad (5)$$

Where p_{nk} is a discrete random variable assuming ± 1 with equal probability and β_{nk} is the log-normal distributed channel coefficient of multipath contribution, k belonging to cluster n. the β_{nk} term can thus be express as follows:

$$\beta_{nk} = 10^{\frac{x_{nk}}{20}} \quad (6)$$

Where x_{nk} is assume to be Gaussian random variable with mean μ_{nk} and standard deviation σ_{nk}. Variable x_{nk} in particular, can be further decomposed as follows:

$$x_{nk} = \mu_{nk} + \xi_{nk} + \zeta_{nk} \quad (7)$$

Where ξ_{nk} and ζ_{nk} are two Gaussian random variable the represents the fluctuation of the channel coefficient on each cluster and so on each contribution, respectively. We indicate the variance of ξ_{nk} and ζ_{nk} by σ_ξ^2 and σ_ζ^2. The μ_{nk} value is determined to reproduce the exponential power decay for the amplitude of the cluster and for the amplitude of multi-path contribution within each cluster. One can thus write.

$$\left\langle \left|\beta_{nk}\right|^2 \right\rangle = \left\langle \left| 10^{\frac{\mu_{nk}+\xi_n+\zeta_{nk}}{20}} \right|^2 \right\rangle \hat{=} \left\langle \left|\beta_{00}\right|^2 \right\rangle e^{\frac{T_n}{\Gamma}} e^{-\frac{\tau_k}{\gamma}}$$

$$\Rightarrow \mu_{nk} = \frac{10\log_e \left\langle \left|\beta_{nk}\right|^2 \right\rangle - 10\frac{T_n}{\Gamma} - 10\frac{\tau_{nk}}{\gamma}}{\log_e 10} - \frac{\left(\alpha_\xi^{\ 2} + \alpha_\zeta^{\ 2}\right)\log_e 10}{20} \quad (8)$$

where β_{00} represents the average energy of the first path of the first cluster, while Γ and γ are the power decay coefficient for clusters and multipath respectively. According to (8) the average PDP (Power Delay Profile) is characterized by exponential decay of the amplitude of the cluster, and a different exponential decay for the amplitude of the received pulse within each cluster is shown in the Fig.1. According to the above definitions the channel model represented by the impulse response of (3) is fully characterized when the following parameter are defined [2]:

- The cluster average arrival rate Λ.
- The pulse average arrival rate λ.
- The power delay factor Γ for cluster.
- The power delay factor γ for pulse within a cluster.
- The standard deviation σ_ξ of the fluctuation of the channel coefficient for the clusters.
- The standard deviation σ_ζ of the fluctuation of the channel coefficient for pulse within each cluster.
- The standard deviation σ_g of the channel amplitude gain.

The IEEE suggested an initial set of values for the above parameters. These values where tuned to fit some of the measurement data submitted to IEEE. The values of parameters are utilized to simulate the impulse response of the channel shown in the Fig.8. [9]

V. SIMULATION RESULTS

MATLAB is used to simulate the system and one hundred (100) actual realizations are derived from the channel model given above .System model is simulated in MATLAB [12] using different functions and BER curves are obtained and shown in the Fig.9,10,11.

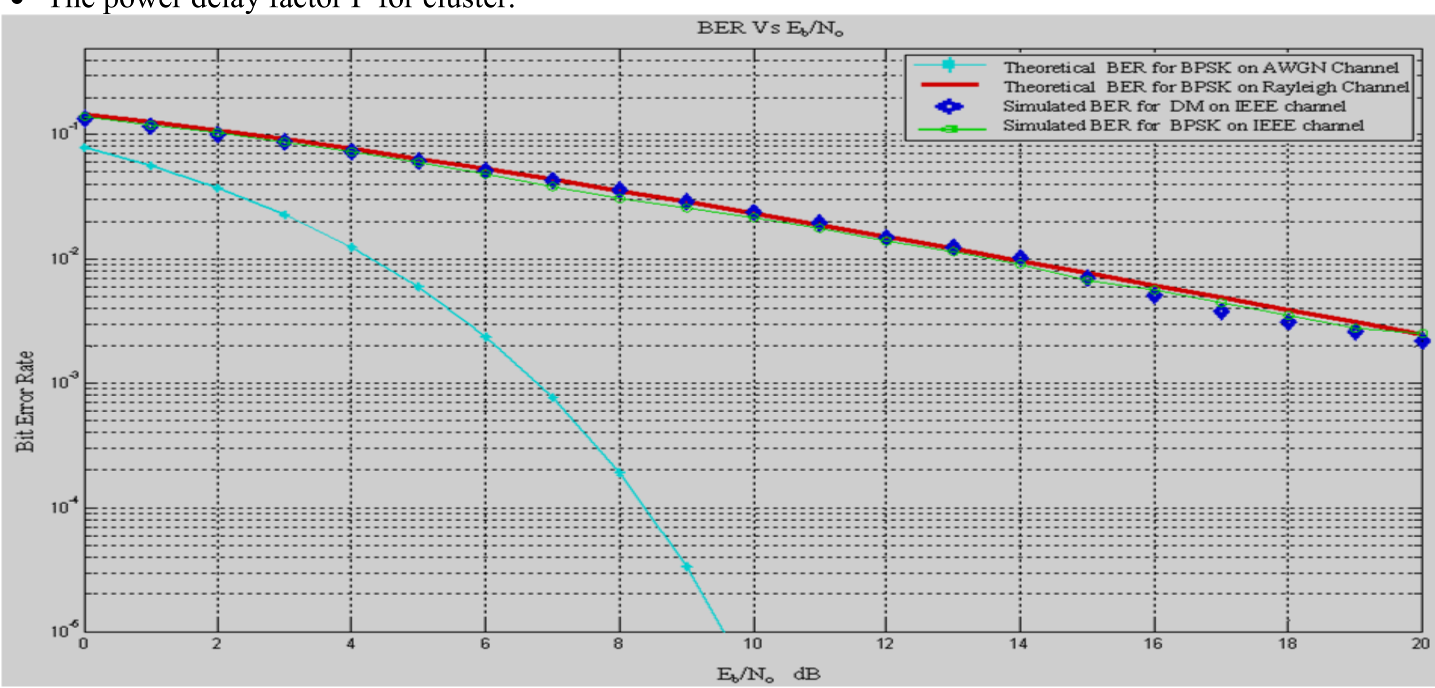

Fig.9 Performance of MC-CDMA for 4- Sub-Carriers

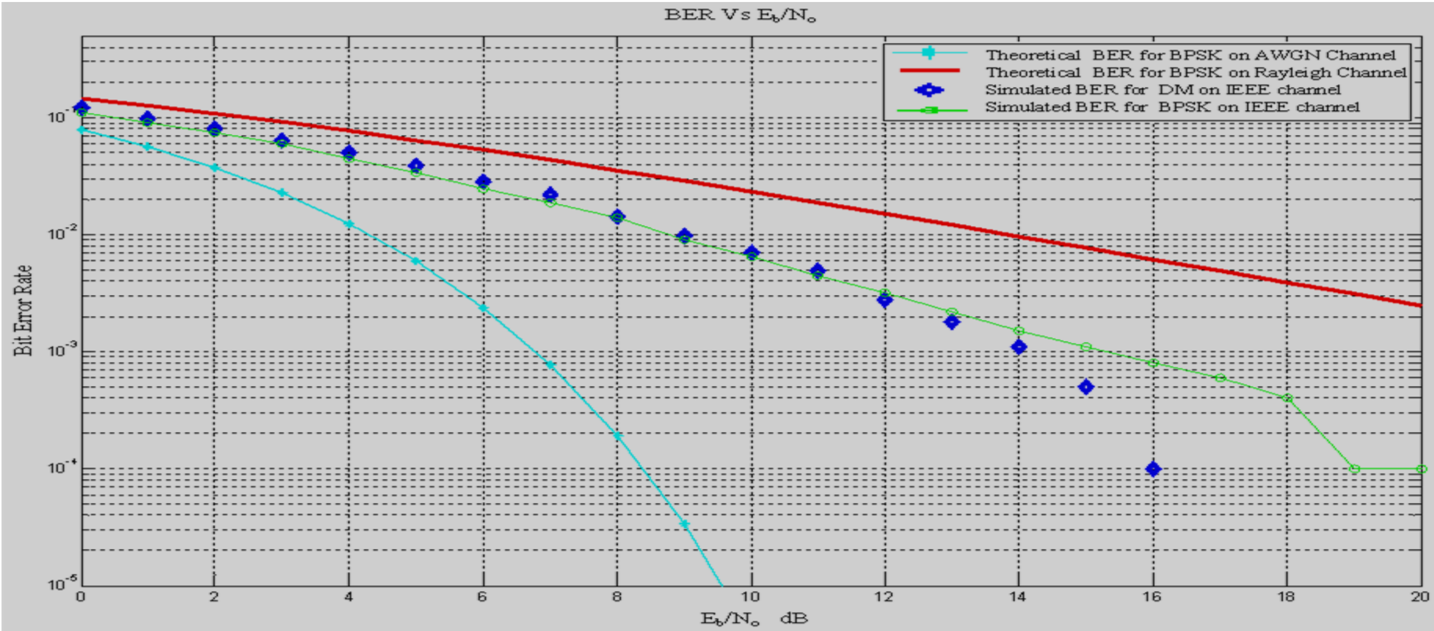

Fig.10 Performance of MC-CDMA for 8- Sub-Carriers

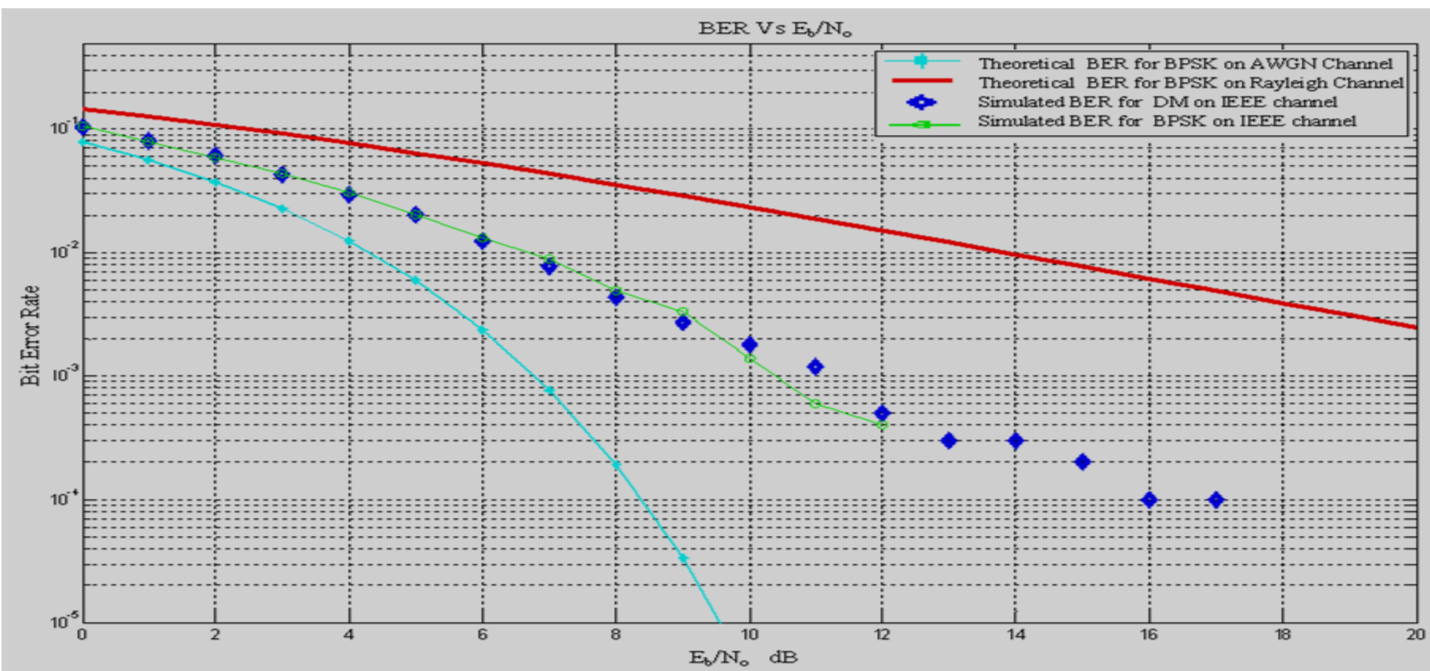

Fig.11 Performance of MC-CDMA for 16- Sub-Carriers

CONCLUSION

BER performance of MC-CDMA over IEEE channel is investigated with modulations BPSK and DM. We are concluding that DM is more suitable as modulation scheme for MC-CDMA. For the lower number of subcarrier performance of DM and BPSK over IEEE channel reach near to theoretical value of BER in Rayleigh fading channel and with increase in the number of carrier in MC-CDMA system its improve BER performance and achieve sustainable BER under the IEEE channel. Hence MC-CDMA system can withstand in IEEE channel and provide considerable BER.

ACKNOWLEDGMENT

The authors would like to thank firstly, our GOD, and all friends who gave us any help related to this work. Finally, the most thank is to our families and to our country INDIA which born us.

REFERENCES

[1] Jeff Foerster, "Channel Modeling Sub-committee Report" Final IEEE P802.15 Working Group February 2003

[2] A Saleh, R Valenzuela., "A Statistical Model for Indoor Multipath Propagation," IEEE JSAC, 1987, vol.5, pp. 128-137.

[3] Theodore S. Rappaport," Wireless communication principles and practice" PHI Publication India ISBN -81-203-2381-5.

[4] Yanjing SUN, Li PENG ,"The Simulation and Analysis of UWB Modified S-V Channel Model" 978-1-4244-3693-4/09 ©2009 IEEE

[5] Athar Ravish Khan, Sanjay M. Gulhane," Performance Evaluation of Time Hopping UWB System in Underground Mine Channel" International Journal of Electronics and Communication Engineering. ISSN 0974-2166 Volume 4, Number 5 (2011), pp. 543-553

[6] Shinsuke. Hara, Ramjee. Prasad, and R. K. Wysocki, "Multicarrier Techniques for 4G Mobile Communications" Artech House, Incorporated, 2003 ISBN 1-58053-482-1.

[7] Shinsuke. Hara and Ramjee. Prasad, "Overview of multicarrier CDMA" IEEE Communications Magazine, vol. 35, pp. 126-133, Dec. 1997

[8] S. Sigdel, K. Ahmed, and R. Rajatheva," Performance evaluation of MC-CDMA uplink system with diversity reception and multiuser detection" IEEE 5th International Symposium on Wireless Personal Multimedia Communications, vol. 2, pp. 650 - 654, Oct.2002

[9] Athar Ravish Khan, Sanjay M.Gulhane, Padmini G. Kaushik "Performance comparison of Ultra Wide Band IEEE Channel and Underground Mine Channel" International Conference on Wireless Communications, Networking and Mobile Computing(WiCom12) Shanghai China . 978-1-61284-683-5/12/ ©2012 IEEE

[10] Shinsuke Hara, and Ramjee Prasad , "Design and Performance of Multicarrier CDMA System in Frequency-Selective Rayleigh Fading Channels "IEEE Transactions on Vehicular Technology, Vol. 48, No. 5, September 1999

[11] S. Kaiser, "OFDM-CDMA versus DS-CDMA: Performance evaluation for fading channels," in Proc. IEEE ICC'95, June 1995, pp. 1722–1726.

[12] Athar Ravish Khan, *"Performance Evaluation of DS-CDMA System Using MATLAB"* International Journal of Advanced in Engineering & Technology**.** ISSN: 2231-1963 Jan 2012 Vol. 2, Issue 1, pp. 269 -281