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BER Performance of OFDM System with various OFDM frames in AWGN, Rayleigh and Rician Fading Channel

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Abstract- Wireless technology has become the most exciting area during the past decades and also brings with it a whole host of complex design issues, concerning network design, signal detection, interference cancellation, and resource allocation. In the field of communication systems Orthogonal Frequency Division Multiplexing (OFDM) is being widely used for bulk data in single frequency band i.e., encoding digital data on multiple carrier frequency and for its ability to enhance the data rate and reduce the bandwidth. In this paper, the comparison of the performance of OFDM system using Quadrature Amplitude Modulation (QAM) under the influence of AWGN, Rayleigh, and Rician fading channels are analysed. Simulation of OFDM signals are carried out with different faded signals by increasing the number of OFDM frames in AWGN, Rayleigh and Rician fading channels to understand the effect of channel fading and to obtain optimum value of Bit Error Rate (BER) for different number of antennas.

***Keywords**: AWGN, BER, ODFM, Rayleigh fading channel model, Ricin fading channel model*

I. INTRODUCTION

OFDM is a very common multicarrier modulation technique to transmit a signal over wireless channels in diverse environment. In this technique the high date rate stream is divided into parallel low data rate and hence prolong the symbol duration by eliminating Inter Symbol Interference (ISI). By overlapping the sub-channels each other to a certain extent the usage of bandwidth is reduced. Inter Carrier Interference (ICI) can be reduced as these carriers are orthogonal to each other [5]. With the advent of FFT/IFFT it became possible to generate OFDM using the digital domain for orthogonality of sub carriers. Figure 1-2 shows a block diagram of a discrete time OFDM system, where an N complex-valued data symbol modulates N orthogonal carriers using the IFFT forming.

In single carrier systems each symbol occupying an entire bandwidth could be lost due to frequency selective fading, but when transmitted on low data parallel streams, symbol time increases and channel become flat fading. OFDM structure basically relies on three principles:

- The IFFT and FFT [6] are used for modulating and demodulating individual OFDM sub carriers to transform the signal spectrum to the time domain for transmission over the channel and then by employing FFT on the receiving end to recover data symbols in serial order.
- The second key principle is the cyclic prefix (CP) as Guard Interval (GI). CP keeps the transmitted signal periodic. One of the reasons to apply CP is to avoid Inter Carrier Interference (ICI).
- Interleaving is the third most important concept applied. The radio channel may affect the data symbols transmitted on one or several sub carriers which lead to bit errors. To encounter this issue we use efficient coding schemes.

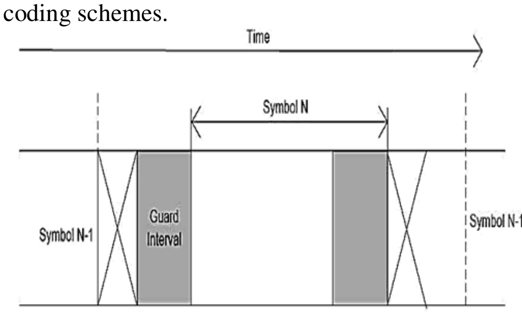

Figure.1: Guard Interval and Cyclic Prefix block diagram.

In OFDM, Guard Interval (GI) is introduced because of multipath propagation as it affects the symbols to delay and attenuate, which causes Inter Symbol Interference (ISI). In GI, Cyclic Prefix (CP) is used to counter Inter Carrier interference (ICI) within an OFDM frame. The CP is simply a copy of the last symbols of the samples placed first, making the signal appear as periodic in the receiver as shown in Figure.1 Before demodulating the OFDM signal the CP is removed. By exploiting the structure imposed using CP.
Symbol synchronization can be achieved. Due to the carrier orthogonality it is possible to use the Discrete Fourier Transform (DFT) and the Inverse Discrete Fourier Transform (IDFT) for modulation and demodulation of the signal [1]. To obtain high spectral efficiency, there can **be** different modulation schemes can be applied i.e. QPSK, 16-QAM, 64-QAM. We will be using 64 – QAM. When compared with different modulations 64-QAM performs better for both the channels but increases the complexity of the system [1]. Implementing various modulation techniques under different fading channels, the performance of BER over Signal to Noise Ratio (SNR) is better for Rayleigh fading channel when

compared with the AWGN and Rician fading channels [4]. This paper generally deals with the performance of the OFDM system under Rayleigh, Rician and AWGN fading environments using 64-QAM by increasing the OFDM.

II. CHANNEL ENVIRONMENT

Fading or loss of signals is a very important phenomenon that related to the wireless communications that leads us to the fading models which try to describe the fading patterns in different environments and conditions. An important issue is in wireless application development is the selection of fading models. Fading refers to the distortion that a carrier-modulated telecommunication signal experiences over certain propagation media. In wireless systems, fading is due to multipath propagation and is sometimes referred to as multipath induced fading. To understand fading, it is essential to understand multipath. In wireless telecommunications, multipath is the propagation phenomenon that results in radio signals' reaching the receiving antenna by two or more paths. Causes of multipath include atmospheric ducting, ionospheric reflection and refraction, and reflection from terrestrial objects, such as mountains and buildings. The effects of multipath include constructive and destructive interference, and phase shifting of the signal. This distortion of signals caused by multipath is known as fading. In other words it can be said that in the real world, multipath occurs when there is more than one path available for radio signal propagation. The phenomenon of reflection, diffraction and scattering all give rise to additional radio propagation paths beyond the direct optical LOS[3] (Line of Sight) path between the radio transmitter and receiver. A Fading Channel is known as communications channel which has to face different fading phenomenon's, during signal transmission. In real world environment, the radio propagation effects combine together and multipath is generated by these fading channels. Due to multiple signal propagation paths, multiple signals will be received by receiver and the actual received signal level is the vector sum of the all signals. These signals incident from any direction or angle of arrival. In multipath, some signals aid the direct path and some others subtract it.

According to the effect of multipath, there are two types of fadings

I. *Large Scale Fading*: In this type of fading, the received signal power varies gradually due to signal attenuation determined by the geometry of the path profile.

II. *Small Scale Fading:* If the signal moves over a distance in the order of wavelength, in small scale fading leads to rapid fluctuation of the phase and amplitude of the signal.

Flat Fading If the bandwidth of the mobile channel is greater than the bandwidth of the transmitted channel, it causes flat fading. Flat fading is one in which all frequency components of a received radio signal vary in the same proportion simultaneously.

There are two types of fading according to the effect of Doppler Spread.

A. *Slow fading*: When the coherence time of the channel is large relative to the delay constraint of the channel then slow fading will occurred. The amplitude and phase change imposed by the channel can be considered roughly constant over the period of use. The events such as shadowing, where a large obstruction such as a hill or large building obscures the main signal path between the transmitter and the receiver, causes the slow fading..

B. *Fast fading*: When the coherence time of the channel is small relative to the delay constraint of the channel causes the fast fading. The amplitude and phase change imposed by the channel varies considerably over the period of use.

There are many models that describe the phenomenon of small scale fading. Out of these models, Rayleigh fading, Rician fading and Nakagami fading models are most widely used.

a) *Rayleigh fading model*: The Rayleigh fading is primarily caused by multipath reception. Rayleigh fading is a statistical model for the effect of a propagation environment on a radio signal. It is a reasonable model for troposphere and ionospheres" signal propagation as well as the effect of heavily built-up urban environments on radio signals. Rayleigh fading [7] is most applicable when there is no line of sight between the transmitter and receiver.

b) Rician fading model: The Rician fading model is similar to the Rayleigh fading model, except that in Rician fading, a strong dominant component is present. This dominant component is a stationary (non fading) signal and is commonly known as the LOS (Line of Sight Component).

c) Additive White Gaussian Noise Model: The simplest radio environment in which a wireless communications system or a local positioning system or proximity detector based on Time of-flight will have to operate is the Additive-White Gaussian Noise (AWGN) [8] environment. Additive white Gaussian noise (AWGN) is the commonly used to transmit signal while signals travel from the channel and simulate background noise of channel. The mathematical expression in received signal $r(t) = s(t) + n(t)$ that passed through the AWGN channel where $s(t)$ is transmitted signal and $n(t)$ is background noise.

An AWGN channel adds white Gaussian noise to the signal that passes through it. It is the basic communication channel model and used as a standard channel model. The transmitted signal gets disturbed by a simple additive white Gaussian noise process.

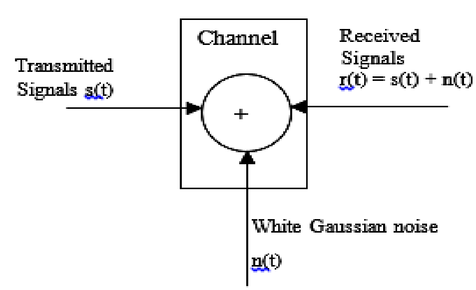

Figure.2: Block diagram of AWGN channel model.

III. QUADRATURE AMPLITUDE MODULATION

One way to communicate a message signal whose frequency spectrum does not fall within that fixed frequency range, or one that is unsuitable for the channel, is to change a transmittable signal according to the information in the message signal. This alteration is called *modulation*, and it is the modulated signal that is transmitted. The receiver then recovers the original signal through a process called *demodulation*.
Modulation techniques are expected to have three positive properties:

I. *Good Bit Error Rate Performance*: Modulation schemes should achieve low bit error rate in the presence of fading, Doppler spread, interference and thermal noise.
II. *Power Efficiency*: Power limitation is one of the critical design challenges in portable and mobile applications. Nonlinear amplifiers are usually used to increase power efficiency. However, nonlinearity may degrade the bit error rate performance of some modulation schemes. Constant envelope modulation techniques are used to prevent the re growth of spectral side lobes during nonlinear amplification
III. *Spectral Efficiency*: The modulated signals power spectral density should have a narrow main lobe and fast roll-off of side lobes. Spectral efficiency is measured in units of bit /sec/Hz.

Digital modulation schemes transform digital signals into waveform that are compatible with the nature of the communications channel. One category uses a constant amplitude carrier and the other carries the information in phase or frequency variations (FSK, PSK). A major transition from the simple amplitude modulation (AM) and frequency modulation (FM) to digital techniques such as Quadrature Phase Shift Keying (QPSK), Frequency Shift Keying (FSK), Minimum Shift Keying (MSK) and Quadrate Amplitude Modulation (QAM).

64-Quadrature Amplitude Modulation:
64-QAM is same as 16-QAM except it is 64 possible signal combinations with each symbol represent six bits (2^6 =64). 64QAM [8] is a complex modulation technique but gives high efficiency. This digital frequency modulation technique is primarily used for sending data downstream over a coaxial cable network. 64QAM is very efficient, supporting up to 28-mbps peak transfer rates over a single 6-MHz channel.

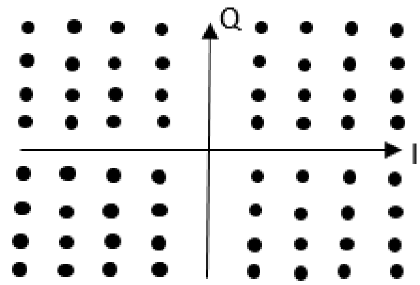

Figure.3: Constellation Diagram for 64- QAM

Bit Error Rate (BER):

The BER, or quality of the digital link, is calculated from the number of bits received in error divided by the number of bits transmitted.

BER= (Bits in Error) / (Total bits received).

In digital transmission, the number of bit errors is the number of received bits of a data stream over a communication channel that has been altered due to noise, interference, distortion or bit synchronization errors. The BER is the number of bit errors divided by the total number of transferred bits during a particular time interval. BER is a unit less performance measure, often expressed as a percentage. Noise affects the BER performance. Quantization errors also reduce BER performance, through incorrect or ambiguous reconstruction of the digital waveform. The accuracy of the analog modulation process and the effects of the filtering on signal and noise bandwidth also effect quantization errors. BER can also be defined in terms of the probability of error POE) and represented in Equation.1

$$POE = \frac{1}{2}\left(1 - erf\right)\sqrt{\frac{E_b}{N_0}}$$

Equation.1: BER in terms of POE

Where erf is the error function, E_b is the energy in one bit and N_0 is the noise power spectral density (noise power in a 1Hz bandwidth). The error function is different for the each of the various modulation methods. The POE is a proportional to E_b/N_0, which is a form of signal-to-noise ratio. The energy per bit, E_b, can be determined by dividing the carrier power by the bit rate. As an energy measure, E_b has the unit of joules. N_0 is in power that is joules per second, so, E_b/N_0 is a dimensionless term, or is a numerical ratio.

Signal to Noise Ratio (SNR)
SNR is the ratio of the received signal strength over the noise strength in the frequency range of the operation. It is an important parameter of the physical layer of Local Area Wireless Network (LAWN). Noise strength, in general, can include the noise in the environment and other unwanted signals (interference). BER is inversely related to SNR, that is high BER causes low SNR. High BER causes increases packet loss, increase in delay and decreases throughput. The exact relation between the SNR and the BER is not easy to determine in the multi-channel environment. Signal to noise ratio (SNR) is an indicator commonly used to evaluate the quality of a communication link and measured in decibels and represented by Equation.2.

$$SNR = 10 \log_{10} (\text{Signal Power / Noise Power})\ dB.$$

Equation.2: Signal to Noise ratio.

E_b/N_0
(Energy per bit to Noise power spectral density ratio)

In digital transmission E_b/N_0 is an important parameter. It is also known as the "SNR per bit used to compare the bit error rate (BER) performance of different digital modulation schemes without taking bandwidth into account. E_b/N_0 is equal to the SNR divided by the "gross" link spectral efficiency in (bit/s)/Hz.

IV. SIMULATION RESULTS

Fading in wireless communications is one of the major topic, demonstrated by the approach available in MATLAB. Here in this paper has discussed about the results obtained from MATLAB simulations. MATLAB provides a simple and easy way to demonstrate fading taking place in wireless systems. The $R_{f\,(}$Radio frequency) signals with appropriate statistical properties can readily be simulated. The different fading models and MATLAB based simulation approaches are described.

I. AGWN CHANNEL SIMULATION

Here, in this paper, AGWN channel has simulated with
No of bits per symbol: 50.
Size of FFT: 128.

Eb / No	BER for		
	64-PSK	64-QAM	2-PSK
-5	0.4981	0.3167	0.2149
0	0.4950	0.2323	0.0805
5	0.4861	0.1635	0.0062
10	0.4622	0.1058	0.0000
15	0.4152	0.0737	0.0000

Table.1: BER values according to various modulations and Eb.

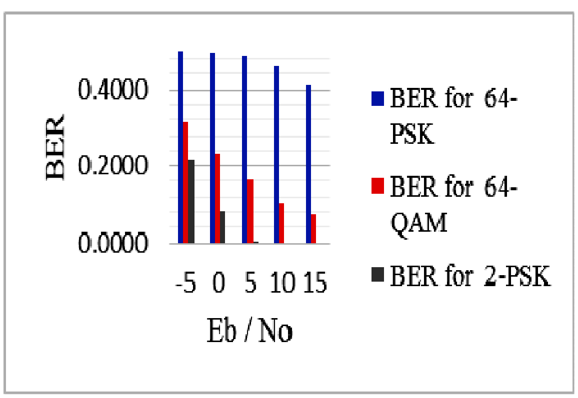

Figure. 4: Graph of Eb/No versus BER for AWGN fading Channel.

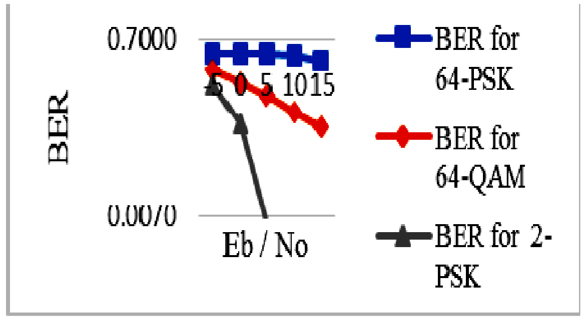

Figure. 5: BER values for AWGN fading Channel.

II. REYLEIGH FADING CHANNEL SIMULATION

Rayleigh fading channel has simulated with fallowing values.
Number of Sub-carriers: 128.
Modulation order: 64.
Modulation Type: QAM.
Cyclic prefix: 16.
Doppler Shift: 0.
Number of Pilot Symbols: 4.
Sampling Period of Channel:
K factor: 10.

Eb / No	BER Values for					
	10^4 OFDM Frames	10^3 OFDM Frames	500 OFDM Frames	100 OFDM Frames	50 OFDM Frames	10 OFDM Frames
-5	0.6577	0.6582	0.6559	0.6603	0.6103	0.6992
0	0.4029	0.4027	0.4163	0.3990	0.4505	0.4858
5	0.1792	0.1783	0.1797	0.1559	0.1310	0.0758
10	0.0644	0.0620	0.0595	0.0480	0.0545	0.0033
15	0.0199	0.0229	0.0127	0.009 2	0.0082	0.0000

Table.2: BER values according to various OFDM frames and Eb.

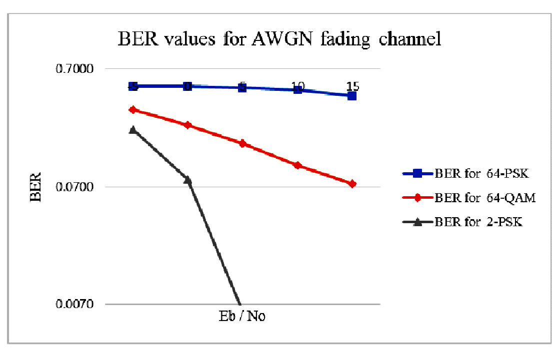

Figure. 6: Graph of Eb/No versus BER for AWGN fading Channel.

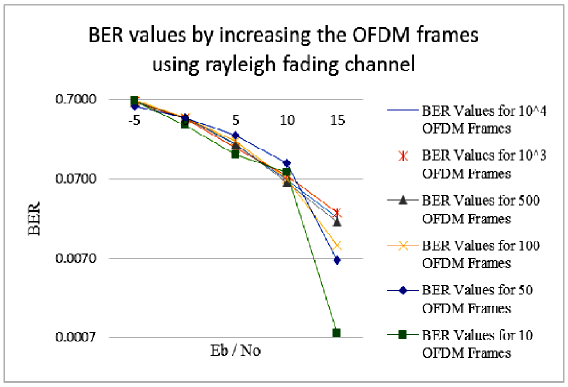

Figure. 7: Graph of BER values versus Frames in rayleigh fading Channel.

III. Eb/No versus BER.

Eb / No	BER Values for		
	Rician fading channel	Rayleigh fading channel	AWGN fading channel
-5	0.6103	0.5885	0.3167
0	0.4505	0.417	0.2323
5	0.1310	0.2477	0.1635
10	0.0545	0.1103	0.1058
15	0.0082	0.0067	0.0737

Table.3: BER values according to various fading channels and Eb.

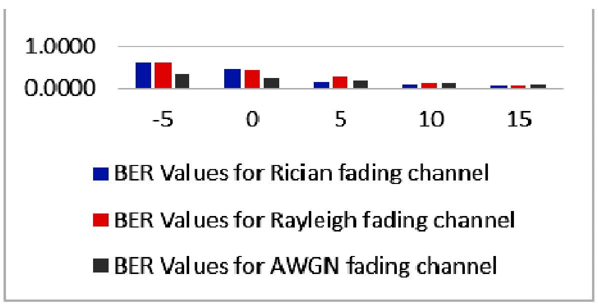

Figure. 8: Graph of BER for various fading Channels.

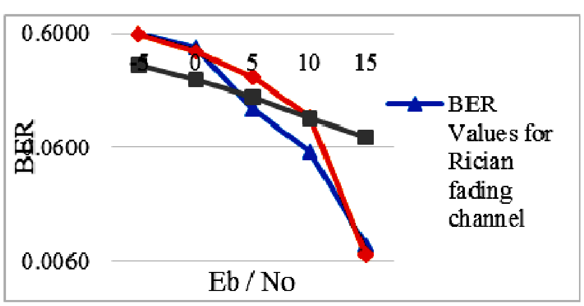

Figure. 9: Graph of Eb/No versus BER for AWGN fading Channel.

V. CONCLUSION.

In this paper, the comparison of the performance of OFDM system using Quadrature Amplitude Modulation (QAM) under the influence of AWGN, Rayleigh, and Rician fading channels are analysed. Simulation of OFDM signals are carried out with different faded signals by increasing the number of OFDM frames in AWGN, Rayleigh and Rician fading channels to understand the effect of channel fading and to obtain optimum value of Bit Error Rate (BER) for different number of antennas. All these work has carried out through the Matlab software and observed the result through the various graphs and concluded that Modulation schemes should achieve low bit error rate in the presence of fading, Doppler spread, interference and thermal noise and also observed that The exact relation between the SNR and the BER is not easy to determine in the multi-channel environment. Signal to noise ratio (SNR) is an indicator commonly used to evaluate the quality of a communication link and measured in decibels. E_b/N_0 is equal to the SNR divided by the "gross" link spectral efficiency in (bit/s)/Hz.

VI. REFERENCE.

[1]. Anurag Pandey and Sandeep Sharma, "BER performance of OFDM System in AWGN and Rayleigh Fading Channel" International Journal of Engineering Trends and Technology, ISSN: 2231-5381, Volume 13, Number 3, July 2014, pp. 126-128.

[2]. A. Sudhir Babu, et al, " Evaluation of BER for AWGN, Rayleigh and Rician Fading Channels under Various Modulation Schemes", International Journal of Computer Applications, ISSN: 0975-8887, Volume 26, Number 9, July 2011, pp. 23-28.

[3]. Mohammed Slim Alouini and Andrea J. Goldsmith "Capacity of Rayleigh fading channels under different Adaptive Transmission and Diversity combing Techniques", IEEE Transaction on Vehicular Technology, ISSN:0018-9545, Volume 48, Number 4, July 1999, pp. 1165-1181.

[4]. Sai Krishna Borra, et al, "Performance Evaluation of OFDM System with Rayleigh, Rician and AWGN Channels, ISSN: 2250-2459, Volume 3, Issue 3, March 2013, pp. 678-682.

[5]. S. Weinstein and P.Ebert , "Data transmission by frequency-division multiplexing using the discrete Fourier transform", Volume 19, Number 5, October 1971,pp. 628-634.

[6]. A. Sadat and W.B. Mikhael, "Fast Fourier Transform for High speed OFDM Wireless Multimedia System," in Proc. of the 44th IEEE 2001 Midwest Symp. On Circuits and Systems. MWSCAS 2001, Dayton., Ohio, 2001, pp. 149-150.

[7]. Yahong Rosa Zheng and Chengshan Xiao, "Simulation models with correct statistical properties for Rayleigh fading channels", IEEE

Transactions on communications, Volume 51, Number 6, June 2003, pp. 920-928.
[8]. Fumiyaki Adachi, "error Rate Analysis of Differentially Encoded and detected 16-APSK under Rician fading", IEEE Transaction on vehicular Technology, ISSN: 0018-9545,Volume 45, Number 1, February 1996, pp. 1-11.
[9]. "Nextel Flash-OFDM: The Best Network You May Never Use". PC Magazine. March 2, 2005. Retrieved July 23, 2011
[10]. Raza Akbar, Syed Aqeel Raza, Usman Shafique, "PERFORMANCE EVALUATION OF WIMAX", Blekinge Institute of Technology, March 2009.
[11]. Dennis Roddy, "Satellite Communcations," Third edition, McGraw-Hill Telecom Engineering.
[12]. Theodore S. Rappaport, "Wireless Communications Principles and Practice," Prentice-Hall of India Private Limited, 2004.
[13]. J. G. Proakis, Digital Communications, McGraw-Hill Inc., New York, NY, 1995 (Third Edition).
[14]. Jingxin Chen, "CARRIER RECOVERY IN BURST-MODE 16- QAM", June 2004.

