Error Rate Performance Analysis of OFDM System over Nakagami-n and Nakagami-q Distributions

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ABSTRACT
The Orthogonal Frequency Division Multiplexing (OFDM) is a multicarrier modulation technique becomes very popular because of its advance used in VLSI. Today it is used in many wireless standards such as WLAN, DAB and ETSI Hiperlan/2.In wireless communication system multi path propagation impairments can be reduce the error rate performance of the system. In this paper, the error rate performance of the OFDM system over Nakagami-n and Nakagami-q fading channels has been investigated. Further these results have been used to evaluate the threshold value of fading figure n and q based on error rate and SNR.

Keywords
OFDM,Fading distribution, Nakagami-m distribution, Nakagami-n distribution, Nakagami-q distribution Rayleigh Fading.

1. INTRODUCTION
Orthogonal frequency divisions multiplex (OFDM) is an efficient technique to overcome the effects of frequency selectivity of the fading channels. OFDM is considered as an effective candidate for the high speed wireless communication systems [1, 2].

The basic approach of OFDM is to divide the high data stream into number of lower rate data stream. Then these data are transmitted over a number of narrowband subcarriers, which are overlapped to each other. Using this modulation technique almost 50% bandwidth can be saved [3-4].In [4] OFDM system carriers are overlapped and to reduce the effect of interference between different modulated carriers orthogonality is required. So the frequency spacing and synchronization of the carriers is select in such a manner that subcarriers are orthogonal, results inter carrier interference removed very efficiently between them.

High spectral efficiency and reduce the effect of inter symbol interference are two main benifits of OFDM systems, therefore it is used in many communication system standards [5]. The high tolerance to ISI makes OFDM more appropriate to high data transmissions than single-carrier modulation transmissions carrier. To solve the problem of inter symbol interference we use cyclic prefix concept. However, diversity techniques can significantly improve the performance of any wireless system over different fading channels. The combination of OFDM systems and diversity become popular in wireless communication system [6].

In wireless communication, perfect modeling of multipath channel is very important for the analysis of the system performance. For the analysis of the multipath fading channel, there are many channel models has been proposed to investigate the statistics of the amplitude and phase of multipath fading signal [8-9].Among them Rayleigh fading channel is basic channel model which is used by the researchers to analyze the design of the system and for the system performance. More recently, the Nakagami-m fading channel [8] has received great interest due to its flexibility and accuracy in matching various experimental data more general than Rayleigh and Rician fading channels.

Nakagami-n (Rice) and Nakagami- q (Hoyt) fading model are two other channel models, which are not gained as much interest as the Nakagami-m and Rayleigh distributions, mainly due to complex nature of their probability density functions. More specially, Nakagami- n distribution [10], can be used as the Rayleigh distribution for a special case, provides the optimum fits to collected data from indoor; outdoor and satellite applications [8]. The Nakagami- n distribution is useful for modeling wireless communication systems when the transmitted signal can move to the receiver along direct path [10].

Nakagami-q model is first time proposed by the Nakagmi, this model is an approximation for the Nakagami-m distribution in the range of fading that extends from the one sided Gaussian model to the Rayleigh model [7]. Further this distribution was analyzed independently by Hoyt [11], and also known as the Hoyt distribution [8]. Generally, this model is used in error rate analysis and other performance analysis related to mobile communications. In [12] used the model to examined the outage probability of the cellular systems. The combination of Hoyt model with the Rice process can be used for the modeling of a two state mobile satellite propagation channel [7].

In general researchers analyze the error rate performance of the OFDM system with different frequency selective fading distributions, but in actually it gained an equivalent attention with flat fading distributions also. In [19] OFDM-BPSK system is analyzed with different Nakagami fading channels. So our motivation behind this paper is further enhance the paper [19] to examine the performance of OFDM system with different modulation technique over flat Nakagami-n and Nakagami-q distribution and to obtain the threshold value of fading parameters.

This paper is organized as follows: In section 2, OFDM system model is described. Section 3 deal with the analysis of simulated results of OFDM system and finally section 4 concludes the paper.

2. MODEL DESCRIPTION
Today implementation of the OFDM system depends on the modern signal processing technology, and for that we use Fast Fourier transform. Here we use BPSK and QPSK as a modulation technique to analyze the OFDM system. The FFT Based OFDM system can be expressed as [17]:

$$S_k = \frac{1}{M}\sum_{i=0}^{M-1} d_i \exp\left(j2\pi ik/M\right) \quad k=0\ldots M-1 \qquad (1)$$

Then the signal is converted to analog and modulated up to the individual carrier frequency. At the receiver side the transmitted signal affected with channel noise and additive white Gaussian noise (AWGN). This distorted received signal is after reconstruction fed into the FFT block for sub-channel reconstruction.

The received data R can be represented as [16]:

$$R=H_i d_i + W_i \qquad i=0,1 \ldots\ldots\ldots M-1 \qquad (2)$$

Where *Hi* denotes the channel impulse response and *Wi* is the AWGN of system. In [14], it is shown that the probability of bit error (P) for a QPSK with no channel distortion in AWGN is given as:

$$P = Q\sqrt{2\gamma} \qquad (3)$$

Frequency non-selective fading is the term used to describe the narrowband models of time varying channels. To characterize the channels statistically we consider the time varying characteristics of multipath channels.

The following Nakagami distributions have been considered for our work.

2.1 Nakagami-n Distribution

The Nakagami-n distribution is also known as the Rice distribution. The channel fading amplitude follows the distribution [8].

$$p(z) = \frac{2(1+n^2)}{\Omega} z \exp\left(-n^2 - \frac{(1+n^2)}{\Omega} z^2\right) I_0\left(2z\sqrt{\frac{(1+n^2)n^2}{\Omega}}\right), z \geq 0 \qquad (4)$$

Where n is the fading figure which ranges from 0 to ∞ and which is related to the Rician K factor by $K = n^2$.

2.2 Nakagami-q Distribution

The Nakagami-q distribution also referred to as the Hoyt distribution is given by [8]:

$$p(z) = \frac{(1+q^2)}{q\Omega} z \exp\left(-\frac{(1+q^2)^2}{4q^2\Omega} z^2\right) I_0\left(\frac{(1-q^4)}{4q^2\Omega} z^2\right), z \geq 0 \qquad (5)$$

Where $I_0(.)$ is modified Bessel function of the first kind, and q is the Nakagami-q fading figure, which ranges from 0 to 1.

3. RESULTS & DISCUSSION

In this section,we present a discussion on error rates performance of OFDM system over Nakagami-n and Nakagami-q fading distributions.

3.1 Under the influence of Nakagami-n (Rice) fading channel

OFDM-QPSK system under the influence of Nakagami-n fading channel is shown in Fig. 1. When we increase the value of n, the error rate performance of the system also increases. Further we increase the value of n beyond a limit then performance of system not increases rather it is decreases. Because according to [8] we can derive the Nakagami-n parameter by the Nakagami-m parameter that means nature of the performance of system should be same. If for the Nakagami-m fading distribution we have a threshold value [16, 17], beyond that performance of the system decreases then same nature of the BER performance should be shown by the Nakagami-n fading distribution. According to our simulation results threshold value for QPSK system is 1.4. Further Fig. 2 is present a comparison between different coherent M-phase modulation for fading parameter n=1.4.

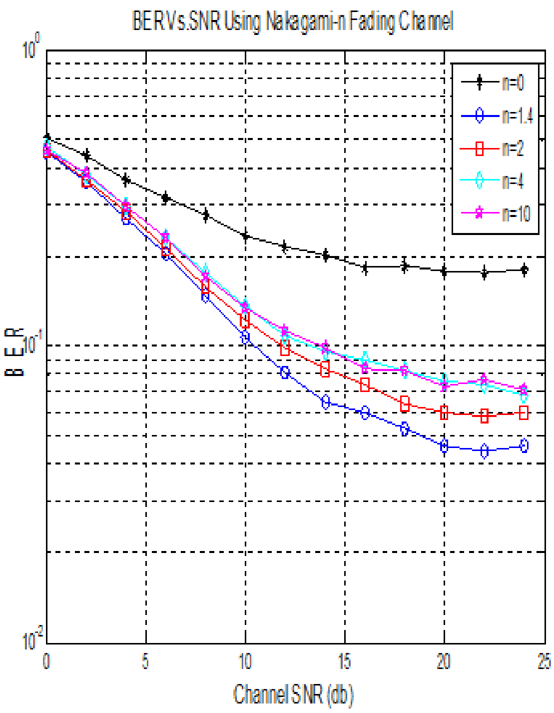

Fig1. BER vs. SNR for OFDM-QPSK system

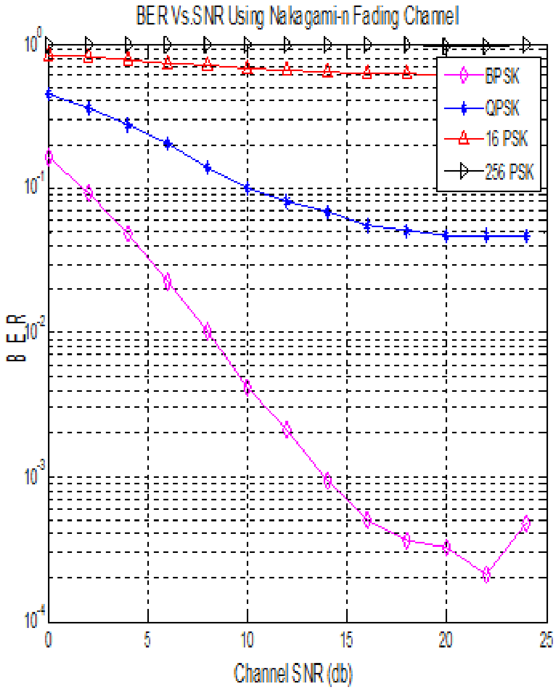

Fig.2. BER vs. SNR for OFDM-QPSK system

3.2 Under the influence of Nakagami-n (Rice) fading channel

OFDM system under the influence of Nakagami-q fading channel is shown in Fig. 3 by varying the value of q. As per previous concept, we discuss for the Nakagami-n distribution, performance of the system increases as we increase the value of q, but further when we increase the value of q beyond a threshold, performance of the system not increases rather it decreases.

Here the threshold value for Nakagami-q is achieved to be .75 through simulation results. Further Fig. 4 is present a comparison between different coherent M-phase modulation for fading parameter q=.2.

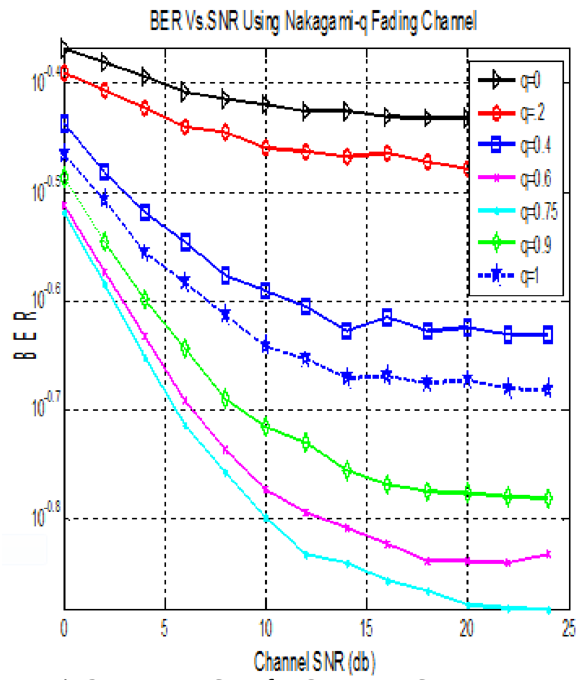

Fig.3. BER vs. SNR for OFDM-BPSK system

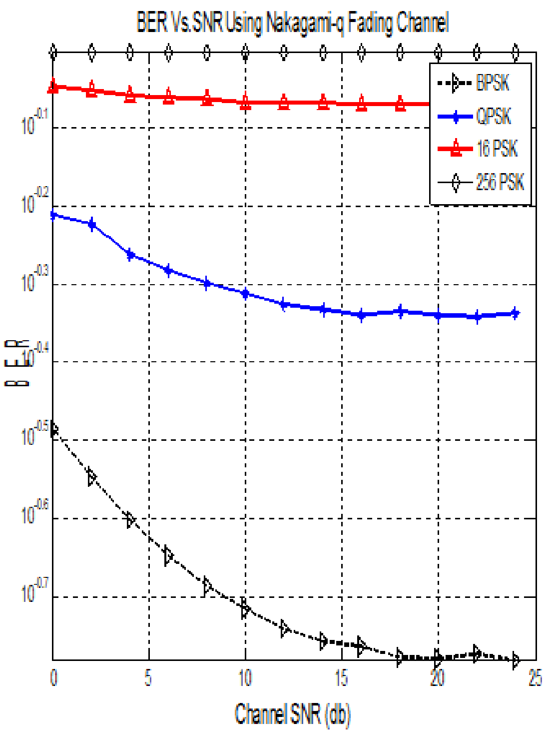

Fig.4. BER vs. SNR for OFDM-BPSK system

4. CONCLUSION

This paper investigate the error rate performance of OFDM systems using coherent demodulation under the influence of frequency non selective Nakagami-q and Nakagami-n fading channels. Basically in this paper we have analyzed error rate performance for signals in Nakagami-n and Nakagami-q fading channels with different fading severity index. Further results have been obtained for threshold value of q and n with flat fading conditions. Based on this approach, performance of various modulations over multipath fading channels can be evaluated. Finally it has been concluded that error rate performance of the OFDM system does not necessarily increase with increasing the n and q.

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BIOGRAPHY

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