COMPARATIVE EVALUATION OF BIT ERROR RATE FOR DIFFERENT OFDM SUBCARRIERS IN RAYLEIGH CHANNEL

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ABSTRACT

In the present situation, the expectation about the quality of signals in wireless communication is as high as possible. This quality issue is dependent upon the different communication parameters. One of the most important issues is to reduce the bit error rate (BER) to enhance the performance of the system. This paper provides a comparative analysis on the basis of this bit error rate. I have compared the BER for different number of subcarriers in OFDM system for BPSK modulation scheme. I have taken 6 varieties of data subcarriers to analyze this comparison. Here my target is to reach at the lowest level of BER for BPSK modulation. That is achieved at 2048 number of subcarriers.

KEYWORDS

Data subcarriers, OFDM, BPSK, BER, Rayleigh fading environment.

1.INTRODUCTION

Multicarrier modulation [1] like OFDM [2] has great applications in present day wireless communication. Bandwidth scalability and higher spectrum efficiency is the most important advantages of this OFDM. It has the ability to minimize Inter Symbol Interference and Inter Channel Interference, where it doesn't have required the equalizer [3]. This OFDM is a multiplexing technique, where large information stream is subdivided into multiple number of small information streams. It is most useful to reduce the bit rate on each of these streams. These streams are modulated and mapped using orthogonal carriers (is known as subcarriers). Effectively, low bit rate signals are transmitted instead of a large bit rate signal. The subcarriers have large channel gains utilize higher order modulation to carry a large number of bits per OFDM symbol. In OFDM, it is very easy to demodulate the received signals without any crosstalk between information in subcarriers.

This OFDM has disadvantage of its sensitivity to non-linear distortion, which is the reason of crosstalk between subcarriers. Finally if it is received at matched filter receiver, then this amount of crosstalk can enhance the error rate. This error rate is deteriorating the quality of received signal. So, first of all we the research workers have required finding and eliminating

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that amount of error rate to boost up the quality of signal. Here I have worked on that issue to find the BER for different number of subcarriers. On this occasion, I have taken BPSK modulation for my experimental analysis. BPSK is lower order modulation, but it has a simple phase calculation with respect to other higher order modulation.

Before this work there have a few works on BER in OFDM. Ref. [2] produced the result on BER for different subcarrier allocation technique. This work is not sufficient for the analysis of comparison between different subcarriers. Ref. [4] investigated BER for different modulation in fading environment. Ref. [5] analyzed the BER for QR decomposition M algorithm. The Authors produced results on the basis of different values of M. Ref. [6] produced another important result of BER for maximum likelihood, coding, modulation etc for different antenna configuration. These works are not sufficient to compare the BER for different values of subcarriers. To the best of my knowledge there have no such work on that issue. So, I have done this work to show the BER for different values of subcarriers.

The rest of the sections of this paper are arranged as follows: Sections 2 describes OFDM technology with its transmission process and resource allocation procedure. Section 3 gives the idea about the modulation schemes under OFDM technology. Simulation and experimental results is showed in 4th Section of this paper. Finally, the whole idea of this paper is concluded in Section 5.

2.OFDM TECHNOLOGY WITH ITS TRANSMISSION PROCESS AND RESOURCE ALLOCATION

In this section I have used to describe the basic OFDM technology and its transmission technique. In serial data transmission, symbols are transmitted sequentially and the frequency spectrums of each data symbol are allowed to occupy in the whole available bandwidth [7].

A parallel data transmission system provides the different possibilities to resolve many of the problems came across the serial data transmission systems. Several sequential data streams are transmitted simultaneously in parallel system. Therefore, large numbers of data elements are being transmitted at a particular instant of time.

OFDM signals are generated at baseband by acquiring the Inverse Fast Fourier Transform (IFFT) of different modulated subsymbols. Any of the transmitted symbols x_i is taken from multi-amplitude signal constellation. D to A and A to D converters include ideal low pass filters with bandwidth $1/T_b$, where, T_b is the sampling interval. A guard time of length T_g is used to eliminate the inter block interference in OFDM and it preserves the orthogonality of tones [8].

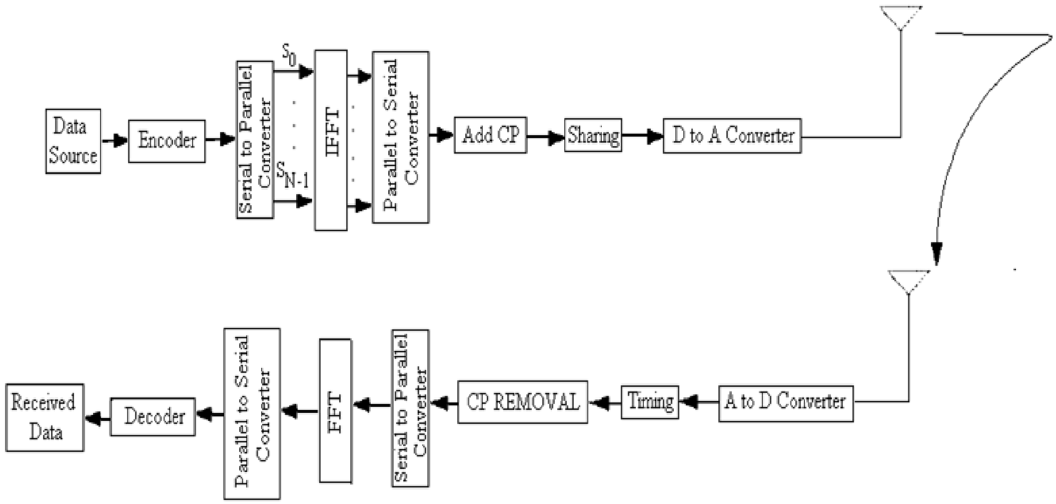

Figure 1: Block diagram of OFDM transceiver system [3]

T_{sym} is the symbol duration, which is mathematically defined as –

T_{sym} = *(Number of samples can be chosen to be the power of 2/Total Bandwidth) + Guard interval;*

This guard interval duration is cyclic prefix(CP) duration. CP is applied to provide a periodic extension to OFDM signal through which a "linear convolution" operation can be executed on the transmitted signal by the channel, can be estimated by "circular convolution" [9].

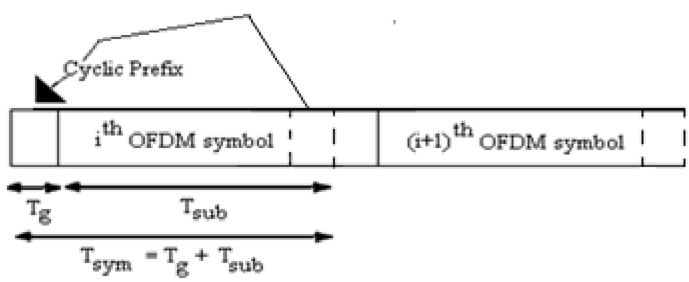

Figure 2: OFDM symbol with CP [3]

Figure 1 describes the overall modulation-demodulation techniques in OFDM system. At the end of the transmitter, block of information-carrying symbols are converted into N number of substreams by using serial to parallel converter [3]. These streams are modulated using N number of orthogonal waveforms with frequency f_l, where, $l = 0, \ldots, N-1$. Output of IFFT in Figure 1 is considered as an overall sum of complex exponential basis functions, complex sinusoids, the harmonics, or tones of multitone signal [10]. If, I consider that one of these tones or harmonics, which is complex exponential function related to a particular subcarrier. Then, it is defined as:

$$x(n)|_{\omega=l\Delta f} = \sum_{l=1}^{N} a_l e^{j2\pi l \frac{n}{N}} \quad \text{....(1)}$$

where, $f_l = l/T_s = l\Delta f$ [Δf is amount of subcarrier spacing and T_s is symbol duration]; here, ω is equivalent with f_l.

If the channel response H_i (there are total $L+1$ number of channels) is operated on input transmitted signal then final output can be defined as –

$$y(n) = \sum_{i=0}^{L} H_i x(n - d_i) \quad \text{....(2)}$$

where, d_i is multipath delay of a particular assigned channel.

If linearity issue of OFDM signal is considered for a multipath fading channel, then each of its complex exponential components is also focused to the identical channel model. Consequently, it can be computed that each received subcarrier component of the OFDM signal $(y(n)|_{\omega=l\Delta f})$ as convolution between transmitted signal and channel impulse response. That can be showed by eq. 3 -

$$y(n)|_{\omega=l\Delta f} = \sum_{i=0}^{L} H_i x(n)|_{\omega=l\Delta f} \quad \text{....(3)}$$

After the addition of CP, we can replace it with an expression of $x(n)|_{\omega=k\Delta f} = a_k e^{j2\pi kn/N}$, if and only if the multipath propagation delay is less or equal to the length of CP. Otherwise, a single delay value outside range of CP, we cross OFDM symbol boundary and the orthogonality between subcarrier components can be lost. First of all, it is assumed that delay spread is lying within a range of the length of CP. So, overall received subcarrier component can be expressed as a function of transmitted subcarrier –

$$y(n)|_{\omega=l\Delta f} = \sum_{i=0}^{L} H_i a_l e^{j2\pi l \frac{(n-d_i)}{N}} \quad \text{....(4)}$$

At the receiver end reverse operation of transmitter can be performed using a FFT operation. Sampled signals of receiver are processed to find their origin point of a block and proper demodulation window. At the next level, it has required to remove the CP and N' $(N' = N)$ point sequence is to be converted from serial to parallel form and supplied it to the FFT. The outputs of this FFT are symbols modulated on N subcarriers, each multiplied by complex channel gain. Depending upon availability of channel information, different types of demodulation or decoding can be used to pick up the information bits. The output of the multipliers is then integrated over the interval of 0 to T to recover the estimated signals $A'_{k,0}$ ... $A'_{k,N'-1}$, which are then converted from parallel to serial form of data and binary form of transmitting signal is obtained after decoding.

Due to cause of time-varying nature of wireless channel, dynamic resource allocation makes full utilization of multiuser diversity in OFDM to achieve higher performance [11]. In the case of access mechanism of OFDM, subset of subcarriers is allocated to each user and thus the allocation of each user must be pre-scheduled by the system. A basic unit of resource allocation in OFDM access mechanism is subchannel. This subchannel is a group of subcarriers. There is different length of these subchannels. On the basis of the allocation of subchannel, all the mechanisms of resource allocation in OFDM is categorized as – Block, Comb and Random type allocation method. Generally, it is assumed that block type is used in the environment of slow fading channel. Comb Type is utilized to satisfy the requirement for equalization, when the variation of channel is too fast. In case of Random type, the whole channel environment is utilized for fast fading channel. Block type arrangement is utilized to map the pilot subcarriers on all the different subcarriers. Comb type is utilized to map on specific number of subcarriers. In case of Random type, pilot subcarrier indexes can be modified periodically [3, 12-13].

3. MODULATION SCHEMES UNDER OFDM TECHNOLOGY

OFDM have different modulation schemes are different on the basis of channel conditions. These modulation schemes provide certain interaction between spectrum efficiency and bit error rate. OFDM transmitter maps message information into a chain of PSK symbol or QAM symbols which will be consequently converted into N parallel streams. This process is implemented by applying IFFT operator to data stream. Each of N symbols from serial-to-parallel conversion is passed through different subcarriers [14 - 17]. So, one of the most important thing is modulation to describe the performance in my work. At receiver side output of FFT is passed through parallel to serial converter and at that time output of this converter can be detected by the QAM demodulator to detect the exact data. In the next section, I have described the simulation method using BPSK modulation.

4. SIMULATION AND EXPERIMENTAL RESULTS

This work is based on a comparison between BER of different number of subcarriers in OFDM technology. I have used a set of parameters to execute the experimental simulation. Everything of this research work has been done through the simulation in MATLAB. 6 different subcarriers have been taken to perform this work. I have chosen the following simulation parameters and set their specific value as given in Table I. This work has been simulated in MATLAB and validated through Qualnet 6.1 simulation software [18].

Table I. Set up Values of Experimental parameters

Parameters	**Value**
Number of Symbols	1000
FFT size	64
SNR Variation (For this issue)	0 - 35 dB
Modulation Type	BPSK
Channel type	3 Tap Rayleigh

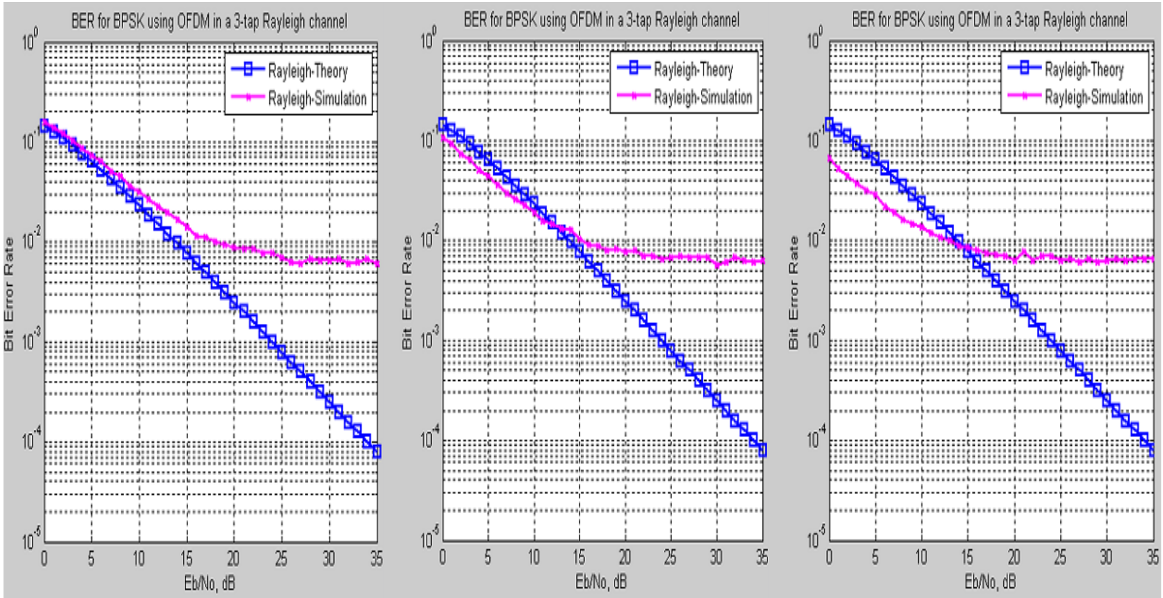

Figure 3: BER for BPSK using OFDM Subcarriers 64, 128, 256 in 3 tap Rayleigh channel

Figure 3 shows the BER for modulation type of BPSK using different types of OFDM subcarriers of 64, 128, and 256. The graphical comparison of figure 3 and 4 proves that BER is lowest for 2048 number of subcarriers. BER is almost fixed after SNR of 15 dB in OFDM technology under 2048 number of subcarriers. In case of 64 numbers of subcarriers, simulated result of BER and theoretical values of BER is almost same upto 10 dB.

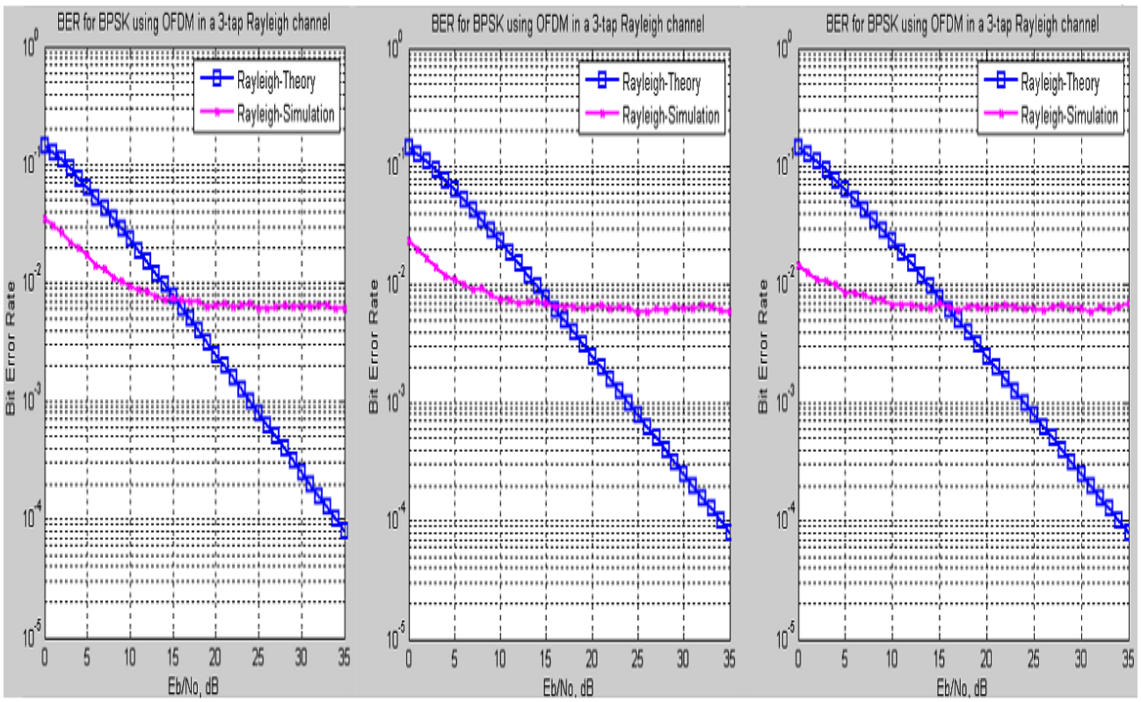

Figure 4: BER for BPSK using OFDM Subcarriers 512, 1024, 2048 in 3 tap Rayleigh channel

Here, it is observed that flat nature of BER curve increases with the increasing order of subcarriers.

5. CONCLUSIONS

This paper explores an idea about the comparative evaluation on the basis of BER for different number of subcarriers in Rayleigh fading model. I have taken the results for 6 standard subcarriers, which is mostly used in latest wireless technology. From output it is clear that simulated result is too poor with respect to theoretical value at higher value of SNR. This total work is verified through the compatible value of Qualnet Software. Finally it is concluded that, better performance with less amount of error in OFDM system is possible to achieve through the higher number of subcarrier size.

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