Performance Elevation Criteria for OFDM under AWGN Fading Channel using IEEE 802.11a

Abhishek Katariya, Amita Yadav, Neha Jain

Abstract– **In this paper, the BER performance of OFDM-BPSK 16 –QAM and 64–QAM system over AWGN fading channel has been reported. Orthogonal Frequency Division Multiplexing (OFDM) is a key technique for achieving high data rates and spectral efficiency requirements for wireless communication systems. However in fading environments the bit error rate (BER) increases. The performance can be improved by using some kind of channel coding. This form of OFDM is called coded-OFDM (COFDM). This paper presents a modeling and simulation of OFDM based on IEEE 802.11a standard. The flexibility of this model is because fading parameters compared to only one in AWGN fading model, which helps to analyze the severity of fading more deeply and this model is versatile enough to represent fading. Finally simulations of OFDM signals are carried with AWGN faded signal to understand the effect of channel fading .The performance of OFDM is compared in terms of BER vs SNR for different modulation formats.**

Keywords: BER, OFDM Additive white Gaussian noise (AWGN), BPSK ,QAM

I. INTRODUCTION

The need for future communication systems to support mobile users with complete real time access to broadband services calls for robustness against fast frequency-selective multipath fadings. An effective solution to this impairment is to adopt the orthogonal frequency division multiplexing (OFDM) as the multiplexing strategy. Orthogonal frequency division multiplexing (OFDM) is an important wideband transmission technique for wireless communication systems. Compared with the other competing wideband transmission technology i.e. multicarrier code division multiple access an OFDM system can reduce or eliminate inter symbol interference (ISI) and is particularly suitable for transmission over fading channel requiring only a relatively simple equalizer at the receiver for a good performance. OFDM has been a very popular technique for more efficient data communications [1]. OFDM has recently been applied widely in wireless communication systems due to its high data rate transmission capability with high bandwidth efficiency, Fading distribution has been employed as another useful and important model for characterizing the fading channel, specially AWGN fading. Another advantage of this channel is best fit for modeling urban multipath channels, could be better or more severe than Rayleigh fading channel.

It has been used in wireless LAN standards such as American IEEE802.11a .The main idea of using OFDM is to avoid problems caused by multipath reflections by sending the message bits slowly enough so that any delayed copies (reflections) are late by only a small fraction of a bit time. In order to maintain high bit rate, multiple carriers are used to send many low speed messages. These massages are combined and transmitted. At receiver, they are combined to make up one high speed message. In this way, the distortion caused by reflections can be avoided [2, 3]. In this work the performance evaluation of Orthogonal Frequency-Division Multiplexing –Fast Fourier Transform (OFDM-FFT) in AWGN wireless channel models. The rest of the paper is organized as follows. Section 2 presents OFDM system architecture, Section 3 Radio Channels, Section 4 presents IEEE 802.11 specifications .The Simulation results are presented in Section 5, Section 6 concludes the paper.

II. OFDM SYSTEM ARCHITECTURE

The OFDM message is generated in the complex baseband. Each symbol is modulated onto the corresponding subcarrier using variants of phase shift keying (PSK) or different forms of quadrature amplitude modulation (QAM). The data symbols are converted from serial to parallel before data transmission. The frequency spacing between adjacent subcarriers is $2\pi/N$, where N is the number of subcarriers. This can be achieved by using the inverse discrete Fourier transform (IDFT), easily implemented as the inverse fast Fourier transform (IFFT) operation. As a result, the OFDM symbol generated for an N-subcarrier system translates into N samples, with the sample being. At the receiver, the OFDM message goes through the exact opposite operation in the discrete Fourier transform (DFT) to take the corrupted symbols from a time domain form into the frequency domain. In practice, the baseband OFDM receiver performs the fast Fourier transform (FFT) of the receive message to recover the information that was originally sent. Figure 2.1 shows the

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basic OFDM system architecture explaining how the modulation is being done and how then it is being transmitted. This figure also explain how the same signal is received and demodulated using the efficient N-point FFT. The most widely used modulation schemes used in OFDM as per IEEE 802.11a standard are BPSK, 16-QAMand 64-QAM [7].

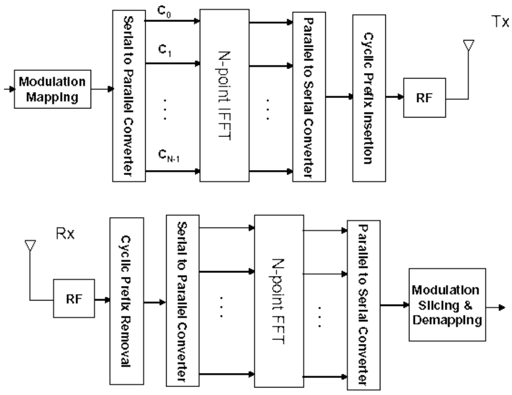

Figure 2.1 Basic OFDM system architecture

The theoretical expressions of symbol error rate (SER) for various uncoded OFDM schemes are as follows.

For BPSK system,(BER and SER)

$$P_{s(orb),bpsk} = \frac{1}{2} erfc\left(\sqrt{\frac{E_s}{N_0}}\right) \qquad \ldots(1)$$

For 16-QAM,

$$P_{b,16-QAM} = \frac{3}{8} erfc\left(\sqrt{\frac{4E_b}{10N_0}}\right) \qquad \ldots(2)$$

For 64-QAM,

$$P_{b,64-QAM} = \frac{7}{24} erfc\left(\sqrt{\frac{18Eb}{126N_0}}\right) \qquad \ldots(3)$$

In OFDM transmission, out of the available bandwidth from -10 *MHz* to +10 *MHz*, only subcarriers from -8.125 *MHz* to +8.125 *MHz* are used. This means that the signal energy is spread over a bandwidth of 16.25 *MHz*, whereas noise is spread over bandwidth of 20 *MHz* (-10 *MHz* to +10 *MHz*), *i.e.*

$$(20MHz) \times E_s = (16.25MHz) \times E_b \qquad \ldots.(4)$$

Simplifying Equation 13, we get $Es / Eb > nDSC / nFFT$. In an OFDM system, the transmission of cyclic prefix does not carry any extra information. The signal energy is spread over time $T_d\, T_{cp}$ whereas the bit energy is spread over the time T_d *i.e.*

$$\frac{E_s}{E_b} = \frac{T_d}{(T_d + T_{cp})} \qquad \ldots(5)$$

III. RADIO CHANNEL

A radio channel is an electromagnetic media between the transmitter and the receiver. The most common channel model is the Gaussian channel, which is generally called the additive white Gaussian noise (AWGN) channel. The AWGN channel is simple and usually it is considered as the starting point to develop the basic system for performance evaluation. Under certain conditions, the channel cannot be classified as the AWGN channel but a multipath fading channel [4]. In an ideal radio channel, the received signal would consist of only a single direct path signal, which would be a perfect reconstruction of the transmitted signal. However in a real channel, the signal is modified during transmission in the channel. The received signal consists of a combination of attenuated, reflected, refracted, and diffracted replicas of the transmitted signal, and the delays associated with different signal paths in a multipath fading channel change in an unpredictable manner and can only be characterized statistically. On top of all this, the channel adds noise to the signal and can cause a shift in the carrier frequency if the transmitter or receiver is moving (Doppler Effect). Understanding of these effects on the signal is important because the performance of a radio system is dependent on the radio channel characteristics [5, 6].

IV. IEEE 802.11 SPECIFICATIONS

IEEE 802.11 is a set of standards carrying out wireless local area network (WLAN) computer communication in the 2.4, 3.6 and 5 GHz frequency bands. The IEEE 802.11a standard specifies an OFDM physical (PHY) layer that splits an information signal across 52 separate subcarriers. Four subcarriers are pilot subcarriers and the remaining 48 subcarriers provide separate wireless pathways for sending the information in a parallel fashion. The resulting subcarrier frequency spacing is 0.3125 *MHz* (for a 20 *MHz* bandwidth with 64 possible frequency slots). The basic parameters for OFDM systems as per IEEE 802.11a standard are given in Table 4.1.

Parameter	Value
FFT size (*nFFT*)	64
Number of subcarriers (*nDSC*)	52
FFT sampling frequency	20 *MHz*
Subcarrier spacing	312.5 *KHz*
Subcarrier index	{-26 to -1, +1 to +26}
Data symbol duration, T_d	3.2 μs
Cyclic prefix duration, T_{cp}	0.8 μs
Total symbol duration, T_s	4 μs
Modulation schemes	BPSK, 64-QAM 16 QAM,

TABLE - 4.1 OFDM TIME BASE PARAMETERS IN IEEE 802.11A

V. SIMULATION RESULTS

The OFDM system is developed, analyzed, and simulated in Matlab version 10. The performance results for such system in three types of modulation are obtained using the OFDM parameters listed below

1. No. of bits per symbol : 52
2. No.of symbols : 10^4

3. FFT size : 64
4. No of data sub carriers: 52
5.

Based on Modulation scheme

$$BER_{BPSK} < BER_{16\text{-}QAM} < BER_{64QAM} \qquad \ldots(6)$$

As discussed earlier, we compare the BER performance of OFDM under AWGN channel conditions. Various schemes used for simulation are BPSK, 16-QAM and 64-QAM.

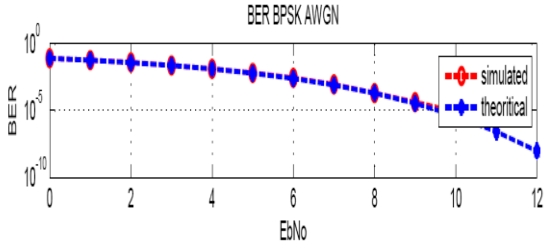

Figure 5.1 BER vs SNR for OFDM-BPSK System

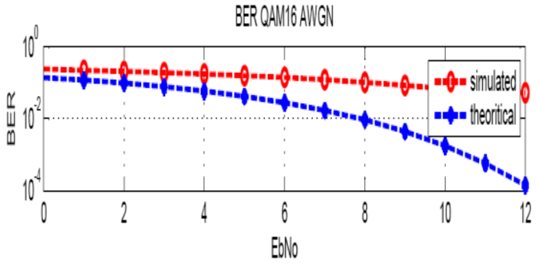

Figure 5.2 BER vs SNR for OFDM-16 QAM System

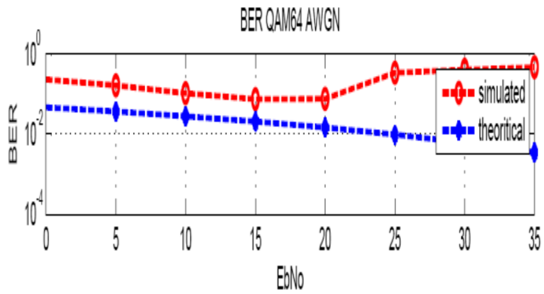

Figure 5.3 BER vs SNR for OFDM-64 QAM System

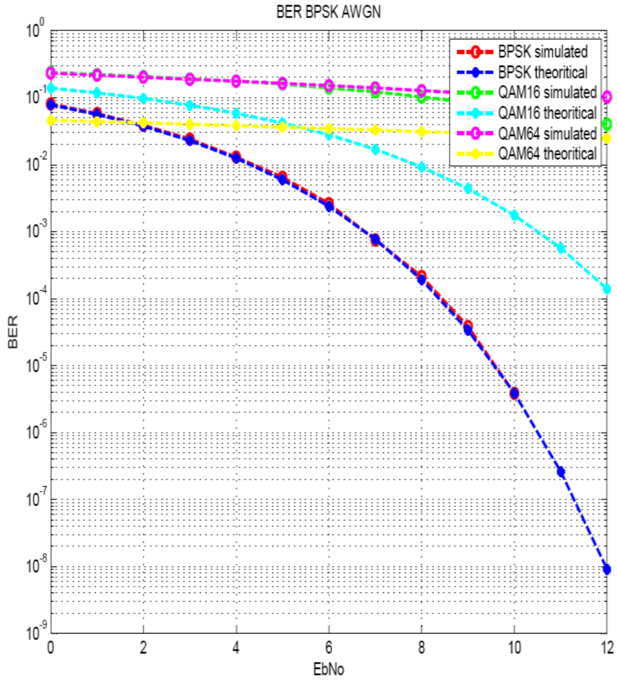

Figure 5.4 BER Comparison of OFDM system under AWGN channel

VI. CONCLUSION

The presence of multipath in wireless OFDM transmission does not allow AWGN channel assumption due to fading. In this paper the performance of OFDM in AWGN wireless channel models is evaluated. In the OFDM systems with AWGN channel, there are wide difference gain from over 64 point at the higher values of SNR, where one can obtain more gains when the SNR increases. The SNR for each modulation takes into account the number of bits per symbol, and so the signal power corresponds to the energy per bit times the number of bits per symbol. The lower Doppler frequency as compared to its performance at the higher frequency. The performance will be reduced as the number of constellation mapping points increased from 8 to 64 point. The higher Eb/No required for transferring data means that more energy is required for each bit transfer. Based on convolution coding the cost/complexity may increase.

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