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Performance Analysis of Random Interleaver for OFDM-IDMA System using AWGN and Rayleigh Fading Channel

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ABSTRACT: This paper provides a review on the orthogonal frequency division multiplexing (OFDM) and interleave division multiple access (IDMA) by using AWGN and Rayleigh fading channel. OFDM-IDMA is a composite communication system. This system has been receiving significant research attention due to their capability to address the problem like inter symbol interference (ISI) and multiple access interference (MAI). In various fourth generation wireless communication system this method most widely used. An efficient random based interleaver is present which is simple and could produce orthogonal interleavers for generating user specific chip level interleaver for different user.

KEYWORDS: IDMA, OFDM-IDMA, Random Interleaver, ISI, MAI

I. INTRODUCTION

Multiple access technique is one of the key techniques which are used in the wireless communication system, mostly in the mobile communication system. Generally multiple access techniques such as FDMA/TDMA/CDMA are suitable for voice communication only and unsuitable for high data rate transmission which is used in 1G/2G/3G systems. Performance of CDMA system is limited by multiple access interference and inters symbol interference (ISI). [1]

Interleave division multiple access (IDMA) most widely used in recent year which can be treated as a special case of code division multiple access (CDMA)[2] Which has much consideration for multiple access communication. It is distinct from CDMA, where Orthogonal or Quasi-Orthogonal signature sequences are used in code domain for user separation. IDMA used for different interleaver to obtain the exact function. Since, user specific interleavers can be generated in simple way for a larger number. The limited number of user specific signal sequence can be bypass which is limitation of CDMA and this exhibit the advantage of IDMA over CDMA.

Orthogonal frequency division multiplexing (OFDM)-interleave division multiple access IDMA is a multicarrier system which is used in new and developing broadband wireless communication systems. The word orthogonal implies that there is a literal relationship between frequencies of the carrier in the system. The idea of composite communication scheme combining OFDM-IDMA has many profits like the analysis of inter symbol interference (ISI) and sufficient reduction of multiple access interference.

High peak to average power ratio (PAPR) is drawback with OFDM-IDMA system. The high PAPR of OFDM-IDMA indicates that if the signal is not to be distorted most of the element in the transmitter and receiver must have a greatest dynamic range. In individual the output amplifier of the transmitter must be very linear over a large range of signals. OFDM-IDMA is precise to frequency offset. Local oscillation and carrier of the received signal can reduced the system performance.

It is implied that achievement of fast fading multiple channel become worse than slow fading channel in the existence of carrier frequency offset[3]. OFDM-IDMA is an encouraging multiple access scheme in wireless communication which as low decoding complexity.

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Section II outlines the OFDM-IDMA system model. In section III describe the different communication channel. Section IV indicate that the comparison of bit error rate of AWGN channel and Rayleigh fading channel and Section V gives the final conclusion.

II. OFDM-IDMA SYSTEM MODEL

Users are analyzed by distinct chip-level interleaving in the OFDM-IDMA system and CDMA is analyzed by distinct signatures. In place of distinct signatures it is used distinct chip-level interleaving in OFDM-IDMA system. Chip-by-chip iterative multiuser detection technique is the main advantage of the OFDM-IDMA system [4]. Multi User Detection (MUD) in IDMA systems become very simple because the complexity of MUD become linear function of the number of users. Compared with the CDMA system, IDMA have very simple MUD algorithm [5]. IDMA can be used to reducing MAI and ISI at lesser complexity. Each user has data in either coded or spreaded form then coded and spreader data are interleaved. All the data are add up because all the data of every user is transmitted at the same time. In the transmission channel an Additive White Gaussian Noise (AWGN) and other multipath channel coefficients added in transmitted data. After this data is reached at mobile station (MS) or every user.

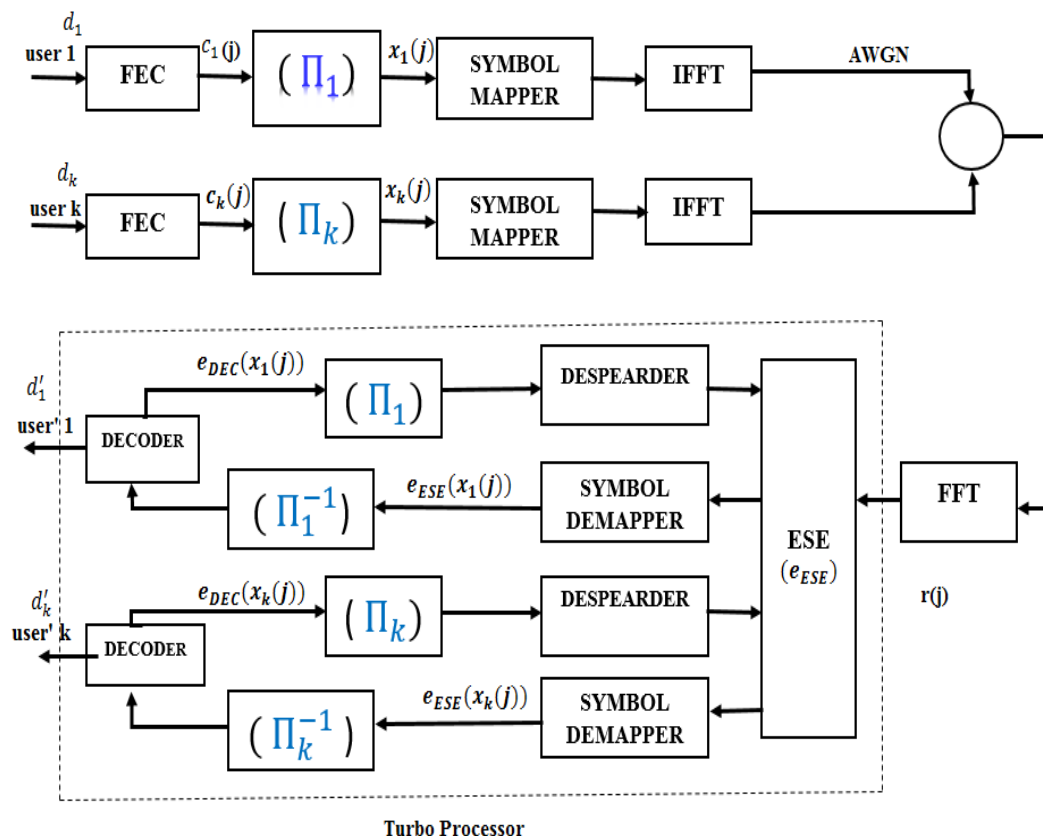


Figure (1) OFDM-IDMA System Model

After this user execute ESE function and find LLRatio and after that data decoded by a posterior probability (APP) decode. The converging of the decoded data for the particular transmitted information is based on the number of iterations. This technique has some errors and this error can be examined by using plot analysing error performance of any system.

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The upper parts of Figure (1) indicate the transmitter section of an OFDM-IDMA system with k simultaneous users. User k has input data sequence d_k which is encoded with the help of a low-rate code C_k . There are different types of FEC (Forward Error Correction) codes given as binary symmetric codes, convolutional codes, block codes, turbo codes, and so on. In this paper we used convolutional codes. The function of convolutional encoder (k/n) encodes the input bits into n coded output bits. Chip-level interleaver π_k is used for interleaved the coded sequence. We get $X(k) = [X_1(j), X_2(j), X_3(j) \dots X_k(j)]$ as per the meeting, we call the elements in X_k "chips". The basic principle of IDMA system is interleaver that required to be distinct for distinct users. It is considered that the interleavers [6] are generated independently and randomly. Interleavers are used to circulate the coded sequences so that the neighbouring chips are approximately uncorrelated and an N point IFFT is used to modulate the sequence on to sub carriers. After filtering the chip, the signal received from k users can be expressed as

$$r(j) = \sum_{k=1}^K h_k x_k(j) + n(j) \quad j = 1, 2, 3, \dots, J \quad (1)$$

The channel coefficient (h_k) for user- k related with (j) . Where (j) are samples of an AWGN (Additive White Gaussian Noise) with variance ($\sigma^2 = \frac{N_0}{2}$). We consider that the h_k (channel coefficient) is known a priori at the receiver section. The received signal goes through orthogonal frequency division multiplexing (OFDM) demodulation system. Demodulation system consists of removal of cyclic prefix and FFT.

Both noise and interference associated with the received signal. The receivers are used to detach the user's data from noise and interference [5]. It is used to divide the work into two sections. In the first section, we isolate the user's data from other data with the help of ESE block. Another section is used to decode the data, noise will be reduced with the help of convolutional decoder block. Both these blocks are used to exchange extrinsic information. The summed data is decoded by ESE using the CBC algorithm [5] proposed by Li ping et al.

III. COMMUNICATION CHANNEL

To transmit the information signal, from transmitter to receiver a channel is used. In wireless communication to transmit the signal a channel is required. Channel can be divided into fast and slow fading channel. In fast fading channel the impulse response is changed while in slow fading channel impulse response is unchanged for several symbols. This paper focuses on the BER analysis of AWGN and Rayleigh fading channel.

A. AWGN

Channel plays an important role for any type of communication system. Noise is one of the factors which affect the performance of communication channel. There are so many factors which cause the AWGN like fluctuation of atoms in conductor, emission from earth, shot noise and other sunny objects and from ethereal sources such as sun. There are different types of communication channels. One of the simplest models of channel is AWGN channel and it is convenient for wired communication. It is LTI (linear time invariant). White Gaussian noise is added to the signal when the signal goes through it. Characteristic of this channel is amplitude frequency response and phase response is flat and linear for all frequencies [7] respectively. It does not exist fading but only distortions occur when modulated signal passes through it.

Received signal can be written as,

$$r(t) = x(t) + n(t) \quad (2)$$

Where, $n(t)$ indicates the noise which has variance as the noise power and Gaussian distribution with zero mean.

$x(t)$ indicates the transmitted signal

B. Rayleigh fading channel

Phase shifting of the channel and multipath conflict edge to the Rayleigh fading. It does not have NLOS (no line of sight) path between transmitter and receiver [8].

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The received signal $R(n)$ can be expressed as

$$R(n) = \sum h(n, \tau)s(n - m) + w(n) \quad (3)$$

Where $w(n)$ represent AWGN noise with zero mean and unit variance and $h(n)$ indicate channel impulse response.

Channel response can be written as

$$h(n) = \sum \alpha(n)e^{-j\theta(n)} \quad (4)$$

Where $\theta(n)$ and $\alpha(n)$ are phase shift and attenuation for n^{th} path.

Magnitude of sum of two identical independent orthogonal Gaussian random variable is Rayleigh distribution and PDF (probability density function) given by

$$P(z) = \frac{z}{\sigma^2} e^{-\frac{z^2}{2\sigma^2}} \quad z \geq 0 \quad (5)$$

Where σ^2 represent the time average power of the received signal and equation (5) represents the Rayleigh random variable.

IV. BIT ERROR RATE

It is the ratio of number of bits with error to the total number of bits that have been transmitted over a given time period that is

$$BER = \frac{\text{number of bits with error}}{\text{total number of bits sent}} \quad (6)$$

It is a key parameter which is estimate the performance of a system along with transmitter, receiver and channel.

BER for BPSK in AWGN channel is given as

$$P_b = \frac{1}{2} \text{erfc} \left(\sqrt{\frac{E_b}{N_0}} \right) \quad (7)$$

Where E_b/N_0 = bit energy to noise ratio

BER for BPSK in Rayleigh fading channel [9] is given as

$$P_b = \frac{1}{2} \left[1 - \sqrt{\frac{\frac{E_b}{N_0}}{\frac{E_b}{N_0} + 1}} \right] \quad (8)$$

Where E_b/N_0 = bit energy to noise ratio

Figure (2) indicate the BER performance for random interleaver of OFDM-IDMA system for user 16, 32, 48 and 64 BPSK modulations. In the simulation user 16 gives the better result as compare to user 32, 48 and 64

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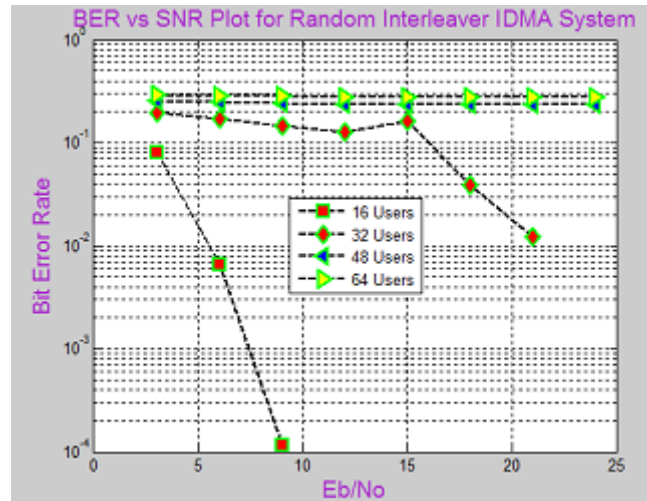


Figure (2). BER performance of random interleaver with OFDM-IDMA for user 16, 32, 48 and 64.

Figure (3) indicate the BER performance of OFDM-IDMA system in Rayleigh fading channel and AWGN channel with TBI. At the time of simulation, the bit energy to noise (E_b/N_0) is taken in dB, for simulation we consider the data length is 128 bits with 15 iteration count along with 16 spread length. Simulation indicates the AWGN channel give the better BER than Rayleigh fading channel.

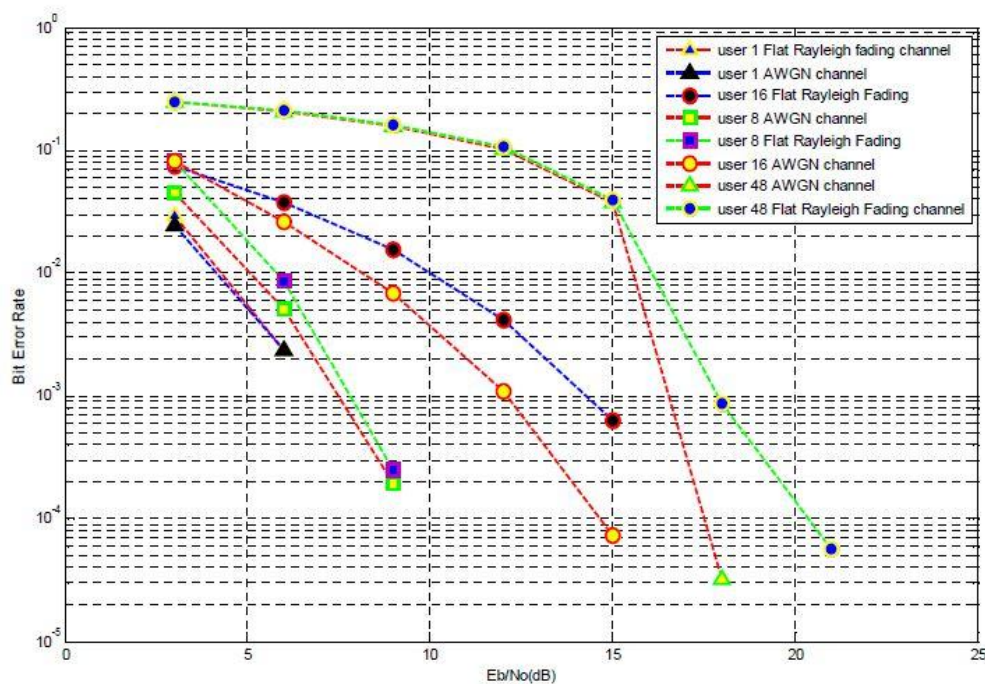


Figure (3). BER Performance of AWGN and Rayleigh Fading Channel

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V. CONCLUSION

In this paper comparison between AWGN channel and Rayleigh fading channel of random interleaver have been done on the basis of parameter like bit error rate(BER). It is conclude that bit error rate of AWGN channel and Rayleigh fading channel distressed by so many aspect like high PAPR, sensitivity of CFO and number of user. In this paper, we consider OFDM-IDMA with random interleaver and conclude that it give the better performance when number of user is less.

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