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PERFORMANCE ANALYSIS OF MULTICARRIER CDMA SYSTEMS

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Abstract: The aim of our study is to find by means of compute simulations the pair of a receiver and a set of the spreading codes able to provide the best BER performance under the mentioned conditions. The simulation results shows that the maximum improvement of the MC-CDMA. This project is to investigate the MUD scheme, and realize a fully functional system in software for developing an algorithm for the detection of multi-users in CDMA system by using a noisy gradient approach. Several techniques are under consideration for the next generation of digital mobile systems, with the aim of improving cell capacity, multi path immunity and flexibilities. These include CDMA and OFDMA. Both these techniques could be applied to providing a fixed wireless system for rural areas. However, each technique as different properties, making it more suited for specific applications and this technique is implemented by MATLAB.

I.INTRODUCTION

Future wireless communication systems must be able to accommodate a large number of users and simultaneously to provide the high data rates at the required quality of service. MC-CDMA[1] is taking the advantage of two advanced technological concepts of wireless communications such as orthogonal frequency division multiplex (OFDM) and the code division multiple access (CDMA), what results especially in high spectral efficiency, the multiple access capability, robustness in the case of frequency selective channels, simple one-tap equalization, narrow-band interference rejection and high flexibility of the MC-CDMA. The outlined potential properties of the MC-CDMA represent the fundamental reasons, why MC-CDMA has been receiving a great attention over the last decade and has been considering to be a promising candidate for the future advanced wireless communication systems. One of the major requirements posed to the MC-CDMA is to reach the required date rate at the acceptable bit error rate (BER) and acceptable complexity for the defined number of the active users. It has been shown that in the case of MC-CDMA systems, the BER at the constant number of the active users is affected especially by nonlinear effects due to the HPA of the MC-CDMA transmitter, MAI resulting from cross-correlation properties of the spreading codes assigned to the particular users and by transmission channel complexity. The analyses of the MC-CDMA signals have shown that due to their multi-carrier nature, the transmitted MC-CDMA[3] signal is characterized by large envelope fluctuation. This property of MC-CDMA signals forces the MC-CDMA transmitter HPA to operate with large input back-off (IBO) in order to keep the required BER and the out-of-band radiation below imposed limits. However, the large IBO[9] will result in inefficient exploiting of HPA and consequently decreasing the coverage of the area of interest by acceptable MC-CDMA signals. As a consequence of this fact, it is crucial to minimize the impact of the nonlinear amplification on the transmission system performance at low IBO.

A.Background

The telecommunications industry faces the problem of providing telephone services to rural areas, where the customer base is small, but the cost of installing a wired phone network is very high. One method of reducing the high infrastructure cost of a wired system is to use a fixed wireless radio network. The problem with this is that for rural and

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urban areas, large cell sizes are required to get sufficient coverage. This presents extra problems as there are long delay times in multi path signal propagation.

Currently Global System for Mobile telecommunications (GSM) technology is being applied to fixed wireless phone systems in rural areas or Australia. However, GSM uses time division multiple access (TDMA), which has a high symbol rate leading to problems with multi path causing inter-symbol interference. Several techniques are under consideration for the next generation of digital phone systems, with the aim of improving cell capacity, multi path immunity, and flexibility. These include CDMA and OFDM. Both these techniques could be applied to providing a fixed wireless system for rural areas. However, each technique as different properties, making it more suited for specific applications.

OFDM is currently being used in several new radio broadcast systems including the proposal for high definition digital television (HDTV) and digital audio broadcasting (DAB). However, little research has been done into the use of OFDM as a transmission method for mobile telecommunications systems. In CDMA, all users transmit in the same broad frequency band using specialized codes as a basis of channelization. Both the base station and the mobile station know these codes, which are used to modulate the data sent.OFDM/COFDM allows many users to transmit in an allocated band, by sub-dividing the available bandwidth into many narrow bandwidth carriers. Each user is allocated several carriers in which to transmit their data. The transmission is generated in such a way that the carriers used are orthogonal to one another, thus allowing them to be packed together much closer than standard frequency division multiplexing (FDM). This leads to OFDM/COFDM providing a high spectral efficiency.Orthogonal Frequency Division Multiplexing is a scheme used in the area of high-data-rate mobile wireless communications such as cellular phones, satellite communications and digital audio broadcasting. This technique is mainly utilized to combat inter-symbol interference, which will be described in the following synthesis.

II.OFDMA

OFDM is a multicarrier transmission technique, which divides the available spectrum into many carriers, each one being modulated by a low rate data stream. It has gained widespread popularity because of its capability to transmit high data rate in a mobile environment, which makes a highly hostile radio channel. This technique has been used in the implementation of (High Performance LAN Type 2 (HIPERLAN/2), IEEE standard 802.11a and 802.16. OFDM is similar to FDMA in that the multiple user access is achieved by subdividing the available bandwidth into multiple channels that are then allocated to users. However, OFDM uses the spectrum much more efficiently by spacing the channels much closer together. This is achieved by making all the carriers orthogonal to one another by spacing them at integer multiples of the symbol frequency. Thus, the peak power of one subcarrier occurs when the power of the other subcarriers are null, thereby countering any effect of interference. The OFDM[5] signal can be to represented as to generate OFDM successfully the relationship between all the carriers must be carefully controlled to maintain the orthogonality of the carriers. For this reason, OFDM is generated by firstly choosing the spectrum required, based on the input data, and modulation scheme used. Each carrier to be produced is assigned some data to transmit.

The required amplitude and phase of the carrier is then calculated based on the modulation scheme (typically differential BPSK, QPSK, or QAM). The required spectrum is then converted back to its time domain signal using an Inverse Fourier Transform. In most applications, an Inverse Fast Fourier Transform (IFFT) is used. The IFFT performs the transformation very efficiently, and provides a simple way of ensuring the carrier signals produced are orthogonal.

A.OFDMA Transmitter and Receiver

The orthogonal carriers required for the OFDM signal can be easily generated by setting the amplitude and phase of each frequency bin, then performing the IFFT. Since each bin of an IFFT corresponds to the amplitude and phase of a set of orthogonal sinusoids, the reverse process guarantees that the carriers generated are orthogonal.

$$S(t) = \sum^{\infty} \left[\sum^{N-1} C_{n,k}\,\varphi_k(t-nT_s)\right]$$

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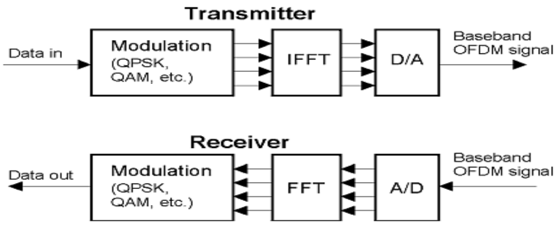

Fig 2.1 Block diagram of OFDMA Transmitter and Receiver

III. MC-CDMA

There are several metrics applied for signal envelope fluctuation quantifying. Here, PAPR has been widely accepted for that purpose. The analyses of the PAPR of the transmitted MC-CDMA signals presented in have shown that PAPR can be reduced by proper selection of the spreading codes. The alternative solutions of MC-CDMA performance improvement can be achieved by the application of additional methods of PAPR reduction and by the compensation methods of the nonlinear distortion due to the nonlinear HPA. The nonlinear distortion compensation methods can be implemented at the transmitter or receiver side of MC-CDMA transmission system. Frequently used solutions at the transmitter side include pre-distortion, tone reservation, active constellation extension, selected mapping, different code allocation strategies , etc. The strategies applied at the receiver side usually combine iterative decoding and nonlinear multi-user detection.

Because of the CDMA exploited in the MC-CDMA structure, the BER reached by the particular users is strongly dependent on MAI. The level of MAI is primarily determined by the spreading codes assigned to the particular users and the transmission channel properties . As the spreading codes for MC-CDMA, Walsh codes, Gold and orthogonal Gold codes, polyphase, Zadoff-Chu codes as well as complementary Golay codes are mostly employed. In the case of wireless MC-CDMA systems, the transmitted signals are firstly nonlinearly distorted and subsequently they are affected by a fading channel. This effects can result in spreading code orthogonality loss and consequently, MAI increasing.Then, the level of the MAI can be reduced by the application of multi-user receivers . As it follows from this short overview of the MC-CDMA performance degradation sources (PAPR, MAI, nonlinear distortion due to HPA), there are a number of approaches how to improve MC-CDMA performance (spreading code selection, PAPR reduction methods, multi-user receiver and nonlinear distortion compensation methods).Here, the application of the nonlinear multi-user receiver and simultaneously the properly selected set of spreading code application are considered as solution.

In this project, we will deal with the performance analyses of MC-CDMA transmission system employing the nonlinear MSF-MUD[] and the different spreading codes. Originally, the MSF-MUD has been proposed in as the multi-user receiver able to compensate the nonlinear distortion due to the HPA of transmitter. The performance properties of the MSF-MUD with regard to the different spreading codes for AWGN channel scenario have been discussed in . This contribution is the extension of our previous study introduced in to the analysis of MSF-MUD performance properties for the frequency-selective fading channel if Walsh codes, Gold and orthogonal Gold codes, polyphase Zadoff-Chu codes and complementary Golay codes are used as spreading sequences. As the nonlinear HPA model, Saleh and Rapp models have been taken into account.

In order to illustrate the MSF-MUD performance, MMSE-MUD will be also applied as the MC-CDMA receivers. Because in the design procedure of the MSF-MUD has been outlined only, the deeper description of the design procedure of the optimum MSF-MUD is included in this project. Since the introduction of OFDM, there are many researches that have been focus to fully exploit the benefits of OFDM either in improving the data rate, the capacity or achieve better spectrum efficiency with the technique. Many researchers have proposed the merger of OFDM and CDMA systems to achieve better spectrum efficiency and also increase the system capacity. This section takes a look at a scheme widely proposed by researchers in this field called the OFDM-CDMA system.

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This system is also known as the MC-CDMA (Multi-carrier CDMA) system. MCCDMA system achieves comparable performance of DS-CDMA, however, the benefits of the MC-CDMA system lies within its flexibility and the relatively simple receiver design. Firstly an OFDM system is used to provide a number of orthogonal carriers, free from ISI. Each carrier is then modulated by an individual code chip to provide a spread spectrum system. In MC-CDMA the spreading code is based on the Walsh-Hadamard coding which ensures that the users do not clash, as the rows are mutually orthogonal.

The core difference between MC-CDMA and DS-CDMA is that the codes that identify different users are modulated in the frequency domain instead of in the time domain. Since the codes are introduced in the frequency domain, there is no need for a rake receiver that complicates the whole system. Therefore, this method greatly simplifies the receiver design. Although MC-CDMA system transmits the signal over different sub-carriers, the overall bandwidth of MC-CDMA is exactly the same as in DS-CDMA[2] as shown in Fig 4. Therefore, there is not any extra cost in term of bandwidth expansion between both the systems. The combination of OFDM signaling and CDMA scheme has one major advantage that it can lower.

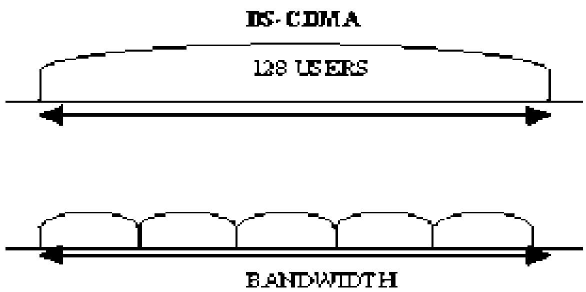

Fig 3.1 DS-CDMA users and Bandwidth diagram

MC-CDMA communication system

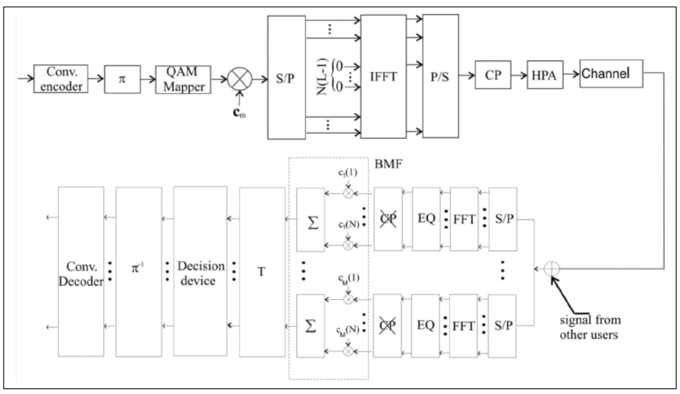

Fig 3.2 Block diagram Of MC-CDMA Communication System

As the spreading sequences, Walsh codes, Gold codes, orthogonal Gold codes, complementary Golay codes and polyphase Zadoff-Chu codes are considered. The PAPR upper bound of the mentioned spreading codes is summarized in below. As it can be observed from this table, the PAPR bound of Golay codes and Zadoff-Chu codes is independent of the spreading code length L. If we assume that the subcarrier number Nc is a multiple of L, then PAPR of the Walsh codes is upper-bounded by $2Nc$.

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The different spreading and it PAPR upper levels values by theoretically

Spreading Codes	PAPR (upper bound)
Walsh codes	$\leq 2N_C$
Gold codes, orthogonal Gold codes	$\leq 2\left[t(m)-1-\frac{t(m)}{L}+\frac{2}{L}\right]$
Golay codes	≤ 4
Zadoff-Chu codes	2

Fig 3.3 Spreading codes With PAPR

Performance of the system for different spreading sequences, using Walsh Code

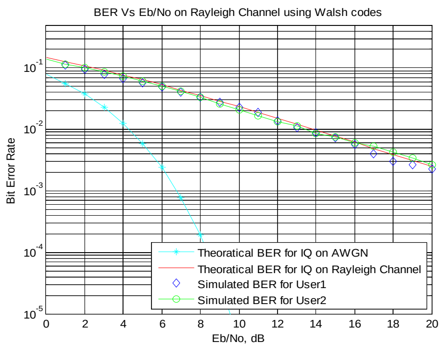

Fig 3.4 Graphs obtained after performance of system using WALSH code

Performance of the system for different spreading sequences, using PN Code

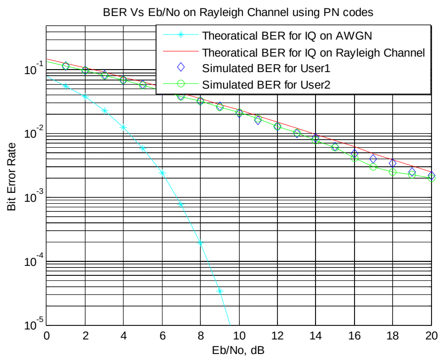

Fig 3.5 Graphs obtained after performance of system using PN code

Performance of the system for different spreading sequences, using Gold Code

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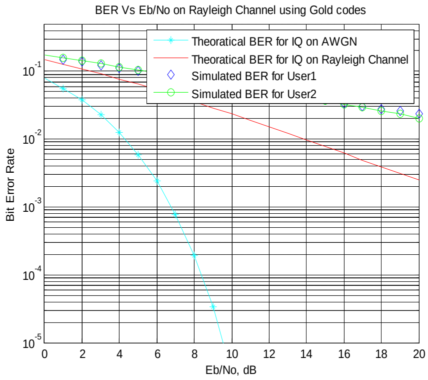

Fig 3.6 Graphs obtained after performance of system using GOLD code

IV.CONCLUSION

In this project, the need and theory for a new spread spectrum technique i.e. Multicarrier CDMA was introduced and the three types of Multicarrier CDMA techniques were presented. The bit error rate for a Rayleigh fading dispersive channel was compared for the DS-CDMA scheme and the MC-CDMA scheme.MC-CDMA combines the advantages of band spreading, code division and frequency diversity of DS-CDMA with the advantages of Multi-Carrier Modulation. Thus, Multicarrier CDMA needs more attention for future implementation on wireless data transmission systems.

We observe results especially in high spectral efficiency, the multiple access capability, frequency selective channels, simple one-tap equalization, narrow-band interference rejection and high flexibility of the MC-CDMA and walsh code provides the greater *BER* than that of Gold and PN codes applications but S/N ratio Gold code is better than that of the Walsh code.

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