Simulation and Analysis of Multicarrier Code-Division Multiple Access

Lekshmi S.R[1], Veena Sagar[2]

[1]*P.G.Scholar, Dept. of ECE, Government Engineering College, Wayanad*

[2]*P.G.Scholar, Dept. of ECE, College of Engineering, Kalloopara*

Abstract

Multicarrier Code Division Multiple Access (MC-CDMA) combines conventional Code Division Multiple Access (CDMA) and Orthogonal Frequency Division Multiplexing (OFDM), so as to allow high transmission rates over severe time-dispersive multi-path channels without the need of a complex receiver implementation. Also MC-CDMA exploits frequency diversity via different subcarriers, and therefore allows the high code rate systems to achieve good BER performances.

In this paper, performance analysis of MC-CDMA under various channels, AWGN channel and Rayleigh channel, is done using various spreading techniques such as Walsh spreading and PN sequence spreading. BER versus SNR graphs are plotted and PAPR values were calculated. These results were compared for finding out which type of MC-CDMA system gives a better performance.

1. Introduction

The concept of using parallel data transmission by means of Frequency Division Multiplexing (FDM) came into existence in the mid-60s. The idea was to use parallel data streams and FDM with overlapping sub-channels to avoid the use of high-speed equalization and to combat impulsive noise, and multipath distortion as well as to fully use the available bandwidth. Initially these applications were used for military communications.

CDMA is a multiplexing technique where a large number of users simultaneously and asynchronously access a channel by modulating and spreading their signals with some pre-assigned codes. The transmitted signal is then recovered by correlating the received signal with the code used by the transmitter. CDMA has been proposed as a candidate for 4G systems [4]. MC-CDMA inherits the interference rejection capability of CDMA, and the potential of mitigating multipath propagation effects of OFDM [1]. Multicarrier CDMA schemes were first proposed in 1993. Multi-Carrier Modulation offers possibilities for alleviating many of the problems encountered with single carrier systems [1]. MC-CDMA is a striking technique for high speed wireless communication as it overcomes the ISI problem and exploits frequency diversity created by multipath propagation [5].

2. Multicarrier Code Division Multiple Access

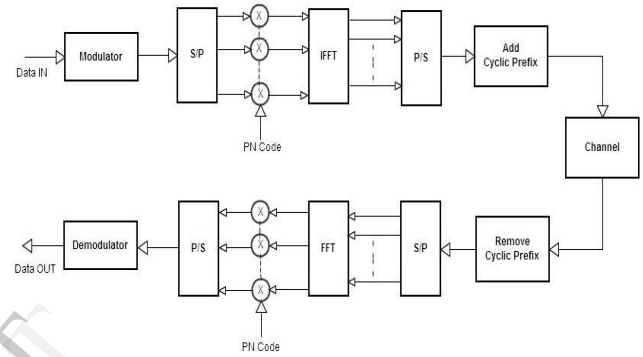

Fig.2.1 Basic block diagram of MC-CDMA

The input data sequence is first modulated and converted into a number of parallel data sequences. Then each data sequence is multiplied by a spreading code. Walsh and PN sequence spreading codes are used for this analysis. The output data in the spreader are then transformed by IFFT and converted back to serial data. The spreading sequence in MC-CDMA provides multiple access capability. A cyclic prefix is inserted in between the symbols to combat inter-symbol interference (ISI) and inter-carrier interference (ICI) caused by multipath fading [2]. The output is then transmitted to the channel. In our simulation, performance of MC-CDMA is analyzed by modeling the channel as AWGN and Rayleigh channels.

The received signal is down-converted after removing the cyclic prefix and then despreaded. This despreaded symbols are then transformed back using FFT. The parallel data coming out from the despreader is converted to serial data and finally demodulated to get the final MC-CDMA output.

3. Channel

There are three basic types of channels namely AWGN, Rayleigh Fading Channel and Rician Fading Channel. In this paper, performance of AWGN and Rayleigh channels are analyzed using MATLAB simulation. Multipath fading is a significant problem in communications. In a fading channel, signals experience fades. When the signal power drops

significantly, the channel is said to be in a fade. This gives rise to high BER [3].

3.1. AWGN Channel

An AWGN channel adds white Gaussian noise to the signal when the signal passes through the channel. Fading, frequency selectivity, interference, nonlinearity or dispersion is not the part of AWGN model [3]. In case of many satellite and deep space communication links, the AWGN model is applicable. But this model is not useful for most terrestrial links because of multipath, terrain blocking, interference, etc.

3.2. Rayleigh Channel

In wireless channels, because of the obstacles and reflectors present, the transmitted signal arrives at the receiver over multiple paths. Such a phenomenon is called multipath propagation. When a signal passes through this channel, it gets fade according to a Rayleigh distribution. If there is no dominant component in between the transmitter and receiver, Rayleigh model is applicable. If there is one dominant component, Rician model may be more applicable.

4. Results and Discussions

The MC-CDMA model for two users is analyzed under various channels using MATLAB 7.12.0.635 (R2011a). We used spreading techniques such as Walsh spreading and PN Sequence spreading to analyze our MC-CDMA system under AWGN channel and Rayleigh channel. BER vs. SNR graphs were plotted to understand the performance of the system under each channel. PAPR values for 1 user at SNR=2dB are calculated and is shown in the Table 1.

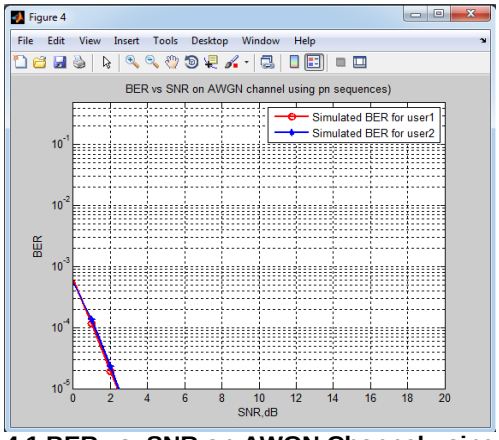

Fig.4.1 BER vs. SNR on AWGN Channel using PN sequences

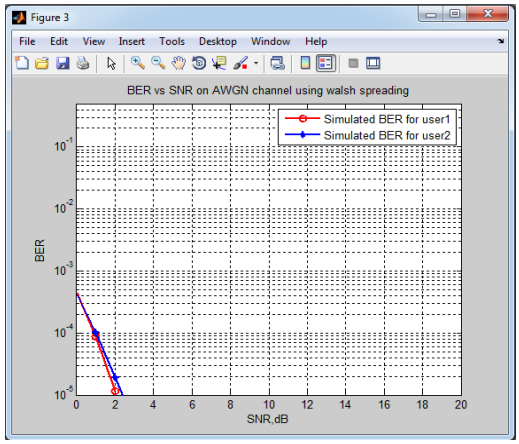

Fig.4.2 BER vs. SNR on AWGN Channel using Walsh spreading

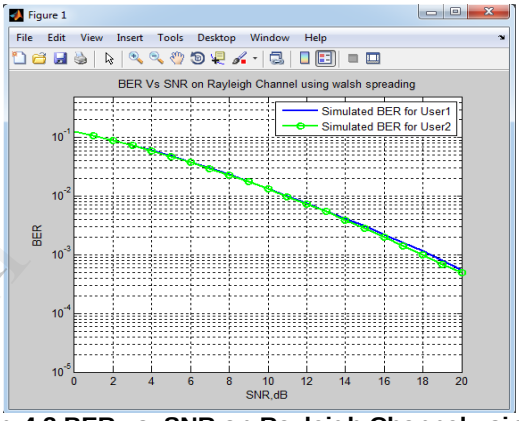

Fig.4.3 BER vs. SNR on Rayleigh Channel using Walsh spreading

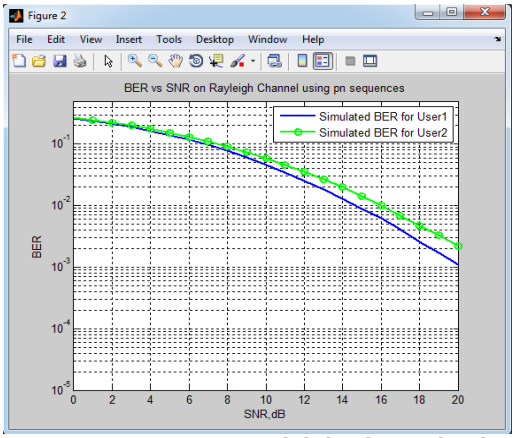

Fig.4.4 BER vs. SNR on Rayleigh Channel using PN Sequences

Table1. BER and PAPR values under different models

TYPE OF CHANNEL	AWGN CHANNEL		RAYLEIGH CHANNEL	
SPREADING TECHNIQUE	WALSH	PN SEQUENCE	WALSH	PN SEQUENCE
BER	0.0839	0.0954	0.1072	0.2374
PAPR	9.7732	9.8345	9.7572	9.7909

From the above table it is clear that BER for Walsh spreading is much lower when compared to PN sequence spreading under two channels. Also, the PAPR value of Walsh is lower than the PAPR value of PN sequence. Hence we can conclude that Walsh spreading is better than PN sequence spreading.

5. Conclusion and Future Works

In this paper, the performance of MC-CDMA system using FFT under AWGN channel and Rayleigh channel with PN sequences and Walsh codes were examined. The generation of PN codes and Walsh codes was successfully done using Matlab programming.

BER versus SNR graphs for multi-users in both AWGN and Rayleigh fading channel were plotted and analyzed successfully. The results indicate that the BER of transmitted bits in Rayleigh channel is greater when compared to that of AWGN channel.

PAPR values for multi-users using various spreading techniques (Walsh spreading and PN sequence spreading) were evaluated. As the PAPR value decreases, the performance of MC-CDMA system increases. Hence, from the obtained results, it can be concluded that the performance of MC-CDMA system using Walsh spreading is better than the system using PN sequence spreading.

Although the use Cyclic Prefix (CP) in Guard Interval is an easy method to mitigate ISI, it leads to spectral inefficiency as well as loss of data throughput. This leads us to the introduction of other multicarrier modulation techniques such as Filtered Multitone (FMT) that do not need the use of the CP. Wavelet based DMT is a form of Filtered Multitone modulation [1].

6. References

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