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Review on MC-CDMA: MC-CDMA, Multiplexing Scheme of CDMA, Advantages of MC-CDMA

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Abstract: MC-CDMA is mainly used for high speed wireless communication because it mitigates the problem of inter symbol interference and also increases the frequency Diversity. MC-CDMA is a combination of Multicarrier transmission and CDMA. Multicarrier CDMA communication is a combination of the multicarrier modulation scheme and the CDMA concept. The basic idea to use multicarrier transmission in a CDMA system is to extends the symbol duration so that a frequency selective frequency channel divided into a no. of narrow band flat fading channels and the complex time domain equalization can therefore be replaced with a relatively simple frequency domain combining. In this paper we study MC-CDMA, its multiplexing scheme, advantages, Disadvantages.

Keywords: MC-CDMA, ICI, ISI, OFDM etc.

INTRODUCTION

Multicarrier CDMA is based on a principle of multicarrier modulation. Multicarrier CDMA communication is a combination of the multicarrier modulation scheme and the CDMA concepts. The multicarrier modulation principle is used in CDMA for extending the Symbol duration so that frequency selective fading channel is divided into a no. of narrow band flat fading channel and the complex time domain equalization can therefore be replaced with a relatively simple frequency domain combining. To understand MC-CDMA, we must understand the technique of multicarrier modulation for single user high speed communicators. Multicarrier modulation is the principle of transmitting high rate data by dividing incoming data into many parallel bit stream each of which has a much lower bit rate. The simplest MCM comes in the form of **STANDARD FREQUENCY DIVISION MULTIPLEXING (FDM)**, where incoming bit sequence is serial to parallel converted and transmitted through low rate, non overlapping sub channel. But MCM cannot give a Significant attention in high speed communication because it has two reasons for this:

(i) It increases the cost because conventional FDM requires steep band pass filter.
(ii) It losses in spectrum efficiency rate guard band in non overlapping FDM.

The first problem can be solved by using faster DSPs and filter bank techniques. A more efficient solution to both problems is the so-called Orthogonal Frequency Division Multiplexing (OFDM). This can be realized by using the Discrete Fourier transform.

MCM/OFDM can be combined with CDMA in several ways to serve multiple-access-communication. Such a communication has the benefits of both MCM and CDMA.

The MC-CDMA scheme is actually a generalized version of the frequency hopping spread spectrum instead of each user using only one sub channel symbols in MC-CDMA are modulated on many sub carrier to introduce the frequency diversity. For this reason MC-CDMA is robust against deep selective fading as regular DS-CDMA. For high speed application one can simply assign mod spreading course to the user to achieve a rate i.e. a multiple of the base rate. The capacity of MC-CDMA is limited by the multiple access interference as in DS-CDMA and carrier frequency dispersion induced ICI. By using frequency diversity combining scheme frequency domain diversity can be easily achieved in MC-CDMA. In wideband application simple receiver design and fast implementation are very important, where the consequently the processing burden and the data rate are very high. In MC-CDMA time diversity within one chip duration each difficult to achieve because sinusoidal waveforms which are used as the sub carriers in the conventional MC-CDMA are not well localized in the time zone domain to solve this problem a cyclic prefix is inserted between consecutive symbols to eliminate residuals inter symbol interference(ISI)[1] due to multipath. The length of the cyclic prefix is equal to or longer than the maximum channel delay spread. This method requires transmitting extra cyclic

prefix, which introduce overhead and does decreases bandwidth efficiency and data rate. A special method has been designed to eliminate such guard intervals for single user OFDM and MC-CDMA system. In this method an overlapped pulse shaping filter is used to change the transmitting signal from stationary to cycle stationary so that a second order method can be derived [2].

MC-CDMA

The MC-CDMA is a combination of multicarrier transmission and CDMA which can be achieved in different ways. The multiplexing of CDMA is divided into two categories [3].

(1) Frequency Domain Spreading:- In MC-CDMA, the multicarrier transmission combines with the frequency domain spreading , the original data stream from a user is spread with this user's specific code in the frequency domain but not with time domain. Each symbol is transmitted simultaneously in a member of subcarrier. Fig (1) shows the transmission and fig(2) shows the receiver structure of the MC- CDMA. It can be seen that the data carrier is 1/N as that of a single carrier DS-CDMA system i.e. the chip duration is N time longer. Therefore the channel delay spread is comparatively shorter. If it is much shorter than the extended chip duration, the original frequency selective fading channel. Thus the complicated time domain equalization can be replaced by a simple gain combining in the frequency domain.

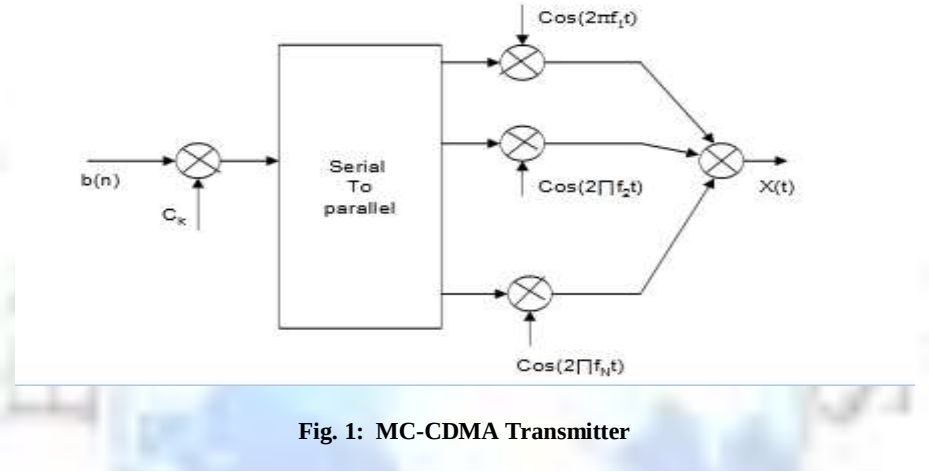

Fig. 1: MC-CDMA Transmitter

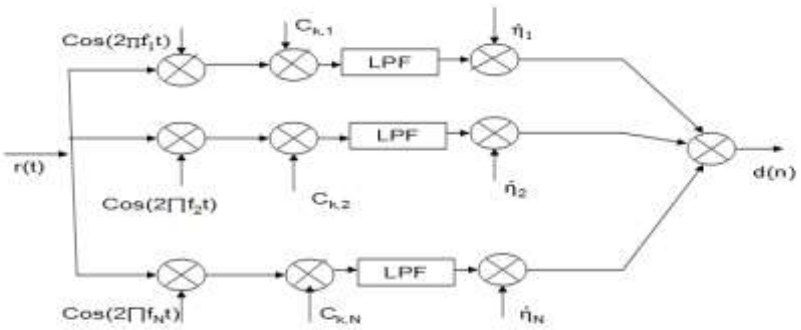

Fig. 2: MC-CDMA Receiver

(2) Time Domain Spreading: MC-CDMA scheme is another way of combining of multicarrier modulation with CDMA in which spreads the original user data stream is in the time domain. As shown in fig [3], the user data stream is first serial to parallel converted into NC (the no. of subcarrier) sub stream, each of which is time spread and transmitted in an individual subcarrier. In other words, a block of NC symbols are transmitted simultaneously. The value of NC can consider according to the system design requirement. However, it is commonly assumed to be equal to the length of spreading code N which will also make comparison with NC – DS – CDMA easier. Using the same spreading code for a particular user, all the symbols are spread in the time domain. This scheme is only used for time-domain-diversity, cannot be used for frequency domain diversity for each individual data symbols. This scheme is more suitable for uplink transmission because it is easy for the establishment of Quasi-synchronization between different users. Fig [4]

gives the basic structure of the receiver of the MS – DS – CDMA system where each branch equals to a single CDMA signal detector.

MT – CDMA is another time domain spreading multicarrier CDMA scheme which was much longer spreading codes so that the bandwidth for each subcarrier signal is about the same as the original DS-CDMA signal. The signals for different subcarriers overlap heavily and do not satisfy orthogonality condition, but longer spreading codes help to eliminate the multiuser interference.

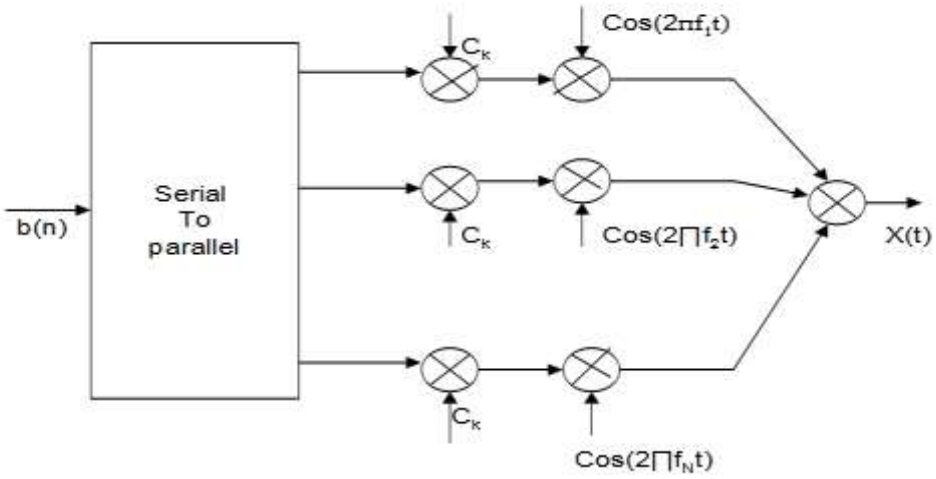

Fig. 3: MC-DS-CDMA Transmitter

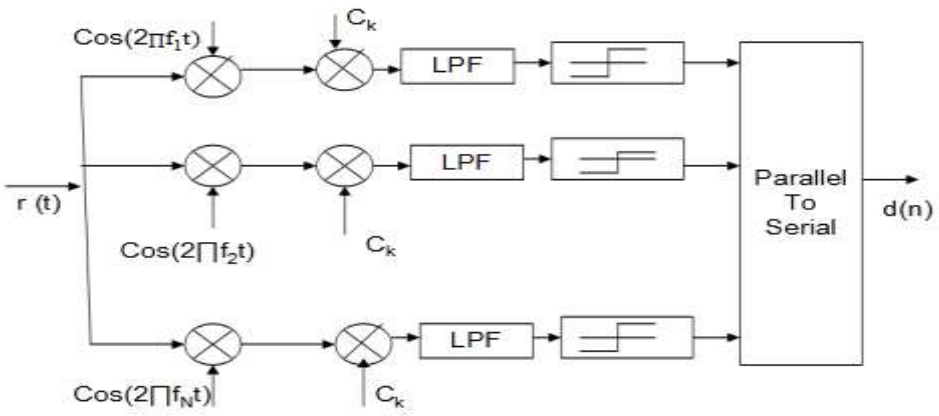

Fig 4: MC-DS-CDMA Receiver

Advantages: - MC-CDMA has following advantages in wireless communication.

1. Synchronization: - Block synchronization can be achieved and maintained in MC-CDMA due to the long chip/symbol duration. Such synchronization is instrumental to multiple user detection.
2. Loading: - with information being transmitted in parallel narrow band stream, it is convenient to employ adaptive loading techniques to distribute transmission power efficiently based on the sub channel SNR to achieve optimum efficient.
3. Parallel transmission: - The main advantages are that the parallel transmission increases the symbol time by modulating the symbol into narrow sub channels. This increase in symbol time makes it more robust to the channel delay spread effects.
4. Less distortion:- In MC-CDMA system each sub channel only undergoes slight distortion. So they were used for high frequency military communication system like the KINEPLEX, ANDEF. Hence multicarrier modulation is a very attractive technique for commercial application as high power Digital Signal processors.

CONCLUSIONS

Due to long chip duration, large loading capacity distributed operation and parallel transmission MC-CDMA is more vulnerable to many limitations. In this paper, we discuss MC-CDMA, multiplexing scheme of MC-CDMA, and advantages of MC-CDMA in wireless communication system. MC-CDMA is classified into: frequency domain spreading and time domain spreading. Different advantages are described in order to prevent various limitations.

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