International Journal of Computational Intelligence Techniques
ISSN: 0976-0466 & E-ISSN: 0976-0474, Volume 3, Issue 2, 2012, pp.-79-81
Available online at http://www.bioinfopublication.org/jouarchive.php?opt=&jouid=BPJ0000221

SUPER FRAME TECHNIQUE TO REDUCE PEAK TO AVERAGE POWER RATIO IN SINGLE CARRIER OFDMA SYSTEM

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Received: October 25, 2012; Accepted: November 06, 2012

Abstract- Single Carrier Frequency division multiple access is a technique which uses a single carrier modulation at the transmitter and frequency domain equalization at the receiver. It provides same performance and same overall structure as those of an OFDMA which has high peak to average power ratio. The advantage of SC-FDMA is its lower PAPR due to its single carrier structure. In this paper, a Super frame using interleaved mapping (SF-IFDMA) is proposed which provides low PAPR. In this paper we simulate and analyze the PAPR for SC-FDMA using super frame mapping. Simulation result shows that the PAPR in the proposed scheme is 3.24 dB.

Keywords- SC-OFDMA with IFDMA, IFDMA with SF-IFDMA, PAPR.

Citation: Singh S., et al. (2012) Super Frame Technique to Reduce Peak to Average Power Ratio in Single Carrier OFDMA System. International Journal of Computational Intelligence Techniques, ISSN: 0976-0466 & E-ISSN: 0976-0474, Volume 3, Issue 2, pp.-79-81.

Introduction

In recent years high speed broad band mobile wireless techniques are desirable for wireless data services. OFDM which is a multicarrier communication technique is widely accepted because of its frequency selectivity of channels which are common in broad band mobile wireless communication. A big advantage of OFDMA is its robustness in the presence of multipath propagation [1]. In spite of some advantage of OFDM they have some drawbacks: high Peak average power ratio, requirement of adaptive scheme for spectral null in the channel, high sensitivity of frequency offset.

A technique that provides similar performance and same overall structure as those of OFDMA system is SC-FDMA which utilizes single carrier modulation. It has the advantage of lower PAPR due to its inherent single carrier structure. SC-FDMA can be used in uplink communication where lower PAPR gives greatly benefits to the mobiles terminals.

Overview of SC-FDMA

The transmitter of an SC-FDMA system the modulation symbols into blocks each containing N symbols of first group in [Fig-1]. N-point DFT produces a frequency domain representation of the input symbols. Then mapping of each of the N-point DFT outputs is done with one of the M (> N) orthogonal subcarriers. If N = M/Q and all terminals transmit N symbols per block, Q simultaneous transmissions without channel interference can be handled [1]. Q is the bandwidth expansion factor of the symbol sequence. As in OFDMA, an M-point IDFT converts the amplitude of subcarrier to a complex time domain signal. The transmitter makes two operations before transmission. Due to multipath propagation, a problem i.e. inter-block interference (IBI) occurs which can be avoided after insertion of a guard band. For this, a set of symbols known as cyclic prefix (CP) is inserted.

The transmitter performs a linear filtering operation referred to as pulse shaping in order to reduce out-of band signal energy. CP being the last part of the block, it is added at the start of each block for two reasons. First reason, CP acts as a guard band between successive blocks. If the length of the CP is longer than the maximum delay spread of the channel, there is no IBI.

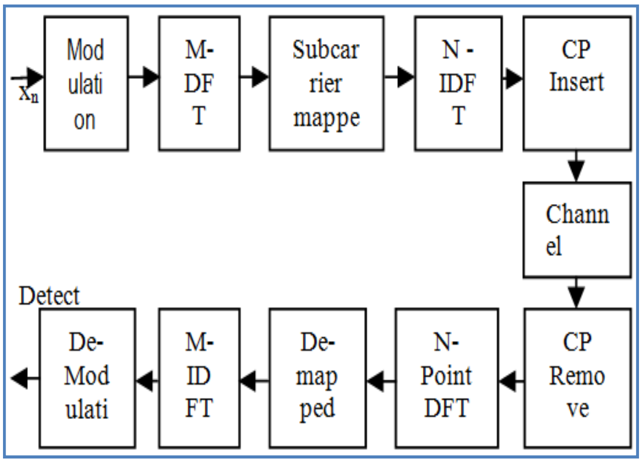

Fig. 1- Block diagram of SC-FDMA

Second reason, since CP is the last part of the block, it converts a linear convolution into circular convolution. The transmitted data propagating through the channel can be modeled as a circular convolution between the channel impulse response and the transmitted data block.

Subcarrier Mapping

Two methods are used for subcarrier mapping: distributed subcarrier mapping and localized subcarrier mapping. In the distributed subcarrier mapping mode, DFT outputs of the input data are occupied by the unused subcarriers, whereas in the localized subcarrier mapping mode, the DFT outputs of the input data are occupied by consecutive subcarriers [2]. Subcarrier mapping mode of SC-FDMA are of two types: localized FDMA (LFDMA) and distributed FDMA (DFDMA). When M = Q×N for the distributed mode with equidistance between occupied subcarriers, another type of SC-FDMA occurs called Interleaved FDMA (IFDMA) is shown in [Fig-2] and [Fig-3].

The peak to average power ratio (PAPR) of IFDMA signal is the same as in the case of conventional single carrier signal.

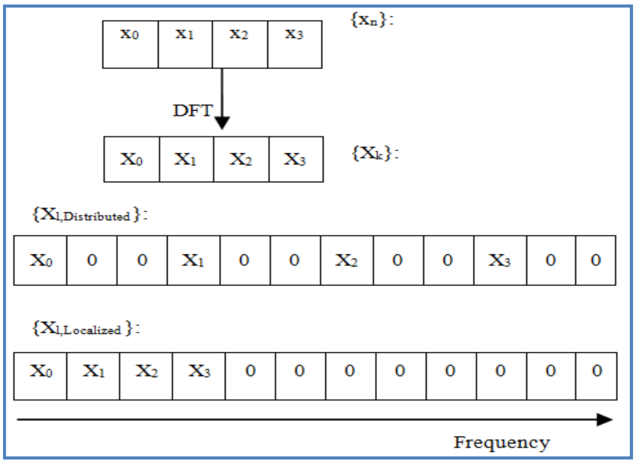

Fig. 2- Transmission of symbols in the frequency domain for $N = 4$ subcarriers per user, $Q = 3$ users, and $M = 12$ subcarriers in SC-FDMA is shown. $X_{l,Distributed}$ denotes transmit symbols for distributed subcarrier mapping and $X_{l,Localized}$ denotes transmit symbols for localized subcarrier mapping.

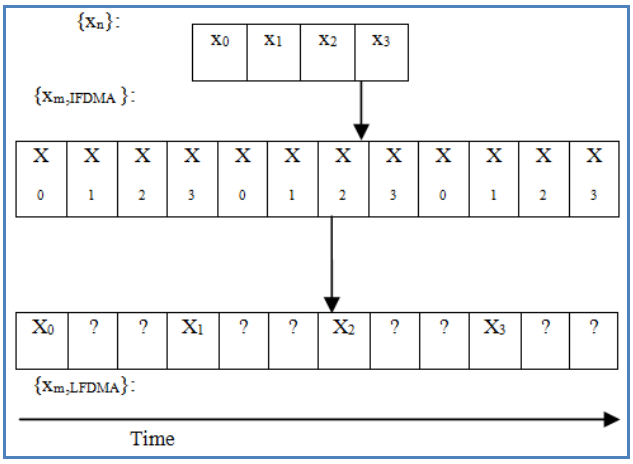

Fig. 3- Transmission of symbols in time domain for $N = 4$, $Q = 3$, and $M = 12$ in SC-FDMA is shown.

Comparison of Paper of SC-FDMA over OFDMA

SC-FDMA is much common with OFDMA and only difference is the presence of the DFT. Its differences that make the two systems perform differently OFDMA performs it on a per subcarrier basis whereas SC-FDMA does it after additional IDFT operation [3]. It is more sensitive to a null in the channel spectrum and it requires channel coding or power/rate control to overcome this deficiency. OFDMA modulated symbols are expanded in the by parallel transmission of the data block during the elongated time period whereas SC-FDMA modulated symbols are compressed into smaller chips by serial transmission of the data block, as in a direct sequence code division multiple access (DS-CDMA) system. PAPR is a performance measurement that is indicative of the power efficiency of the transmitter. A positive PAPR in dB means that we need a power back off to operate in the linear region of the power amplifier and high PAPR degrades the transmit power efficiency performance. The result of [Fig-4] and [Fig-5] Monte Carlo simulations, it is the CCDF (Complementary Cumulative Distribution Function) of PAPR, which is the probability that PAPR in OFDMA is higher than SC-FDMA.

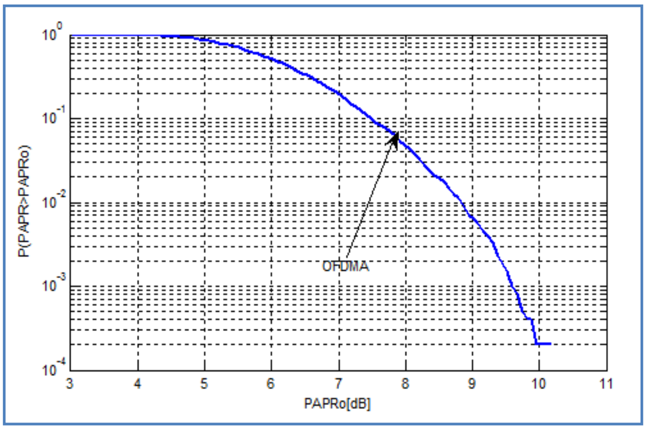

Fig. 4- Comparison of CCDF of PAPR for OFDMA with total number of subcarriers M = 512, number of input symbols N = 128

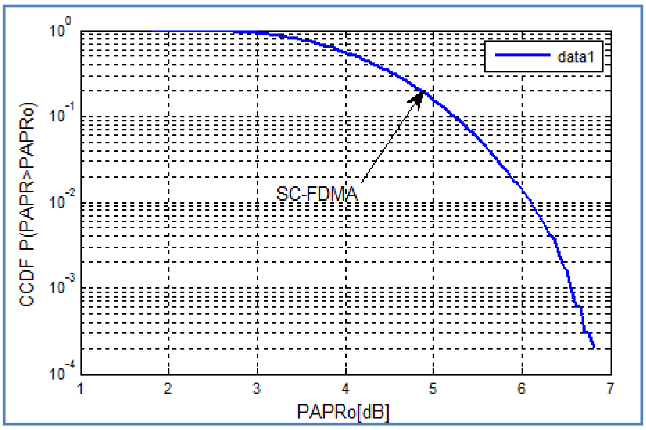

Fig. 5- Comparison of CCDF of PAPR for SC-FDMA with total number of subcarriers M = 512, number of input symbols N = 128

Objective and Description of Super Frame Scheme

In this paper we analyses the PAPR of SC-FDMA signals with super frame scheme and compare it with that of OFDMA is shown in [Fig-6]. B transferred frames in time domain is formed into one super frame with N.B symbol. Super frame with size N.B is divided back into B frames with size N with the condition that the carriers spacing of final divided frame should remain the same as that of the original frame with N subcarriers [4,5]. The OFDMA M point IDFT transforms the subcarrier mapping to produce time domain signal X^s_m. The super frame with lowered PAPR is divided come back into B frames.

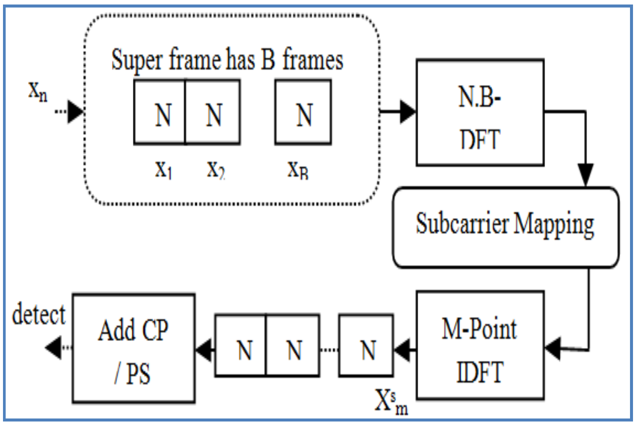

Fig. 6- The structure of the transmitter using SC-OFDM with super frame scheme

The use of a super frame allows the DFT and the IDFT to represent X_k^s and X_m^s respectively in a more accurate representation form. This form makes the output of the IDFT have less PAPR. The proposed scheme works even better when N is small. Even when N is large enough, the proposed scheme gives a little improvement on PAPR reduction.

Simulation Results

To get the performance of the proposed IFDMA with super frame scheme for reducing PAPR, we assume that randomly generated data are 16-QAM modulated and the number of subcarriers is N = 64 and 128 respectively, with B=4. [Fig-7] gives the comparison of complementary cumulative function (CCDF), P(PAPR > $PAPR_0$) between IFDMA and the proposed scheme. PAPR of IFDMA signal with N = 64 is 3.87 dB, while it is 3.24 dB under our proposed scheme. Our scheme has 0.6 dB improvement over IFDMA to reduce PAPR.

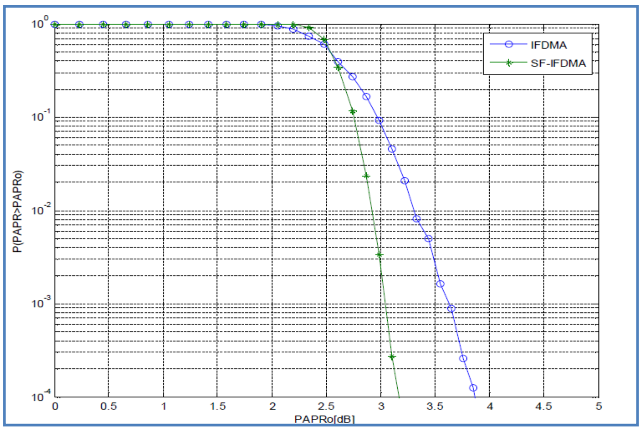

Fig. 7- CCDF for IFDMA and the proposed scheme with N = 64 and B = 4

Conclusion

The super frame technique (SF-IFDMA) is most suitable for the IFDMA systems with small number of subcarriers N, for example N ≤ 128. This scheme is very effective in reducing the PAPR in IFDMA systems, especially when N is small. It can achieve significant reduction of PAPR without requirement of and side information.

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