REDUCTION OF PAPR USING HELICAL INTERLEAVER IN PTS TECHNIQUE FOR SCFDMA SYSTEM

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ABSTRACT

OFDM is a high data rate modulation technique used in the downlink of 4G system. Due to the difficulty of PAPR, usage of OFDM system affects the battery period of mobile terminal. So that new accessing technique called SCFDMA system which is employed in the uplink system. But still the PAPR problem persists in SCFDMA system which has to be overcome. A statistical method, Partial Transmit Sequence can be used with SCFDMA to reduce the PAPR even more. In this paper, the PAPR in SCFDMA system is reduced further by PTS technique using helical interleaver. The proposed system yields 3% reduction in PAPR compared to conventional method.

Keywords—OFDM, SCFDMA, PAPR, PTS

I. INTRODUCTION

One of the major criteria for uplink system in telecommunication is to efficiently use the battery life of mobile terminals [1]. Orthogonal Frequency Division Multiplexing (OFDM) is the attractive technology in wireless communication with the main drawback of Peak to Average Power Ratio (PAPR) problem. This problem happens when the subcarriers loses its orthogonality. So new method called Single Carrier FDMA (SCFDMA) [2], is utilized in uplink system which has less PAPR comparatively. In SCFDMA, the frequency-domain signals are obtained by using DFT before OFDM modulation to the time domain signals. This system has frequency diversity gain by spreading the frequency domain signal from DFT of SCFDMA over multiple subcarriers. This system also has the issue of PAPR for higher order modulation techniques [3]. Many distortion and distortion less techniques are available for PAPR reduction [4]. In PAPR distortion technique, the loss of message bits will take place whereas in distortion less technique the PAPR is reduced by statistically combining phase factors with subcarriers and computation of PAPR of signals will be done from which less PAPR signal will be selected for transmitssion [5].

In the proposed work, helical interleaver is used in PTS technique for SCFDMA system which reduces the similarity among the phase factor combinations which in turn reduces the similarity among subcarriers. The reduction of similarity among subcarriers reduces the PAPR problem in this system [6].

This paper is organized as follows, section II characterizes the SCFDMA system [7]. Section III presents the working of SCFDMA with PTS technique. Section IV discusses about the proposed work of SCFDMA system with PTS using Helical Interleaver. Section V discusses about the analysis of simulation results obtained for proposed work. Section VI provides the conclusion of this paper [8, 9].

II. SCFDMA SYSTEM

SCFDMA is the pre-coded version of OFDM system. This system has additional block of M- point DFT and subcarrier Mapping compared to OFDM system which is to allot M number of users to (N/Q) number of subcarriers, where q is the bandwidth allocation factor to each and every user. In the Figure 1, the data bits from the source are modulated using efficient digital modulation scheme. The parallel data streams from serial to parallel converter are transformed to frequency domain using M- point DFT block where M is the number of users. After this process, each and every user will be allotted with (N/Q) number of subcarriers with the help of N-point IFFT block. The allocation of number of subcarriers to each

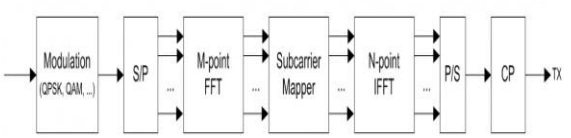

Fig. 1. Block Diagram of SCFDMA System

user is done with the help of subcarrier mapping. In subcarrier mapping two types are there, Localized SCFDMA (LFDMA) and Interleaved SCFDMA (IFDMA) [10]. In LFDMA method subcarriers are placed in adjacent manner. In IFDMA method, the M-point signals are placed in interleaved manner in N- point subcarriers. Then Cyclic Prefix is added to the serially converted subcarriers [12].

III. SCFDMA WITH PTS

Partial Transmit Sequence (PTS) is one of the statistical methods employed to lessen the Peak to Average Power Ratio of multicarrier modulation scheme [13]. It is used in SCFDMA system as shown in the figure 2 to decrease the PAPR even further [14]. In this SCFDMA system, after subcarrier mapping the signals are divided into 'm' number of sets which is represented by,

$$F = \sum_{m=0}^{M-1} F^m \qquad (1)$$

where F is signals obtained from subcarrier mapping. These F signals separately performs IFFT operation which is represented by Equation 2,

$$f^{(m)} = IFFT(F^{(m)}) \qquad (2)$$

After this operation, each set of IFFT transformed signals are multiplied with different combination of phase factors which is denoted as follows,

$$\tilde{f} = \sum_{m=0}^{M-1} c_m f^{(m)} \qquad (3)$$

From the Equation 3, the f with minimum PAPR will be chosen for transmission.

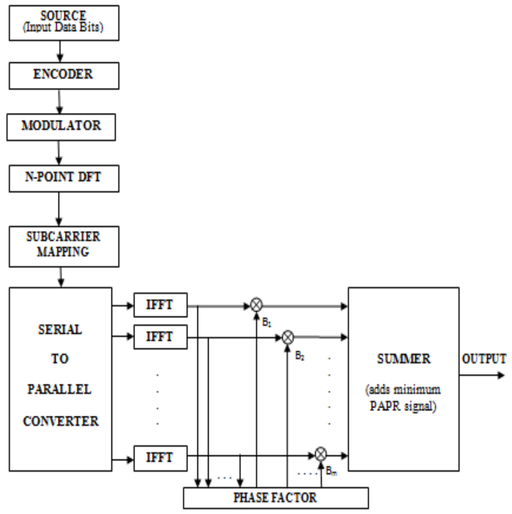

Fig. 2: Block Diagram of SCFDMA system with PTS Technique

The Peak to Average Power Ratio can be obtained using the formula in the Equation 4,

$$PAPR = 10\log_{10} \frac{|f|_{peak}^{2}}{f_{rms}^{2}} \quad (4)$$

where f_{peak} is the highest peak amplitude subcarrier and f_{rms} is the Root Mean Square value of the subcarriers. It is used to find how many subcarriers are having high peak level compared with average peak of all subcarriers. The PAPR persist in SCFDMA usually because of similarity among the different subcarriers due to loss of orthogonality [15].

In Figure 2, the data from source are encoded, modulated and then frequency domain transformation done using M-point DFT block. Then these signals will be mapped to N- points using subcarrier mapping block. These N-points signals are then divided in to 'm' sets. This 'm' set of signals undergoes IFFT operation. After this, IFFT transformed signals are combined with phase factors of different combinations and after computation of PAPR, the less PAPR signal will be selected for transmission. This method reduces PAPR effectively but has the difficulty of computational complexity [16].

IV. PROPOSED WORK

In the proposed method as shown in the figure 3, helical interleaver is used to interleave the different phase combinations of phase factors employed. The helical interleaving for p_x number of phase factors and p_y number of phase combinations is represented as follows,

$$h = i(p_x + 1) \bmod (p_x p_y) \quad (5)$$

where '*i*' is represented as follows,

$$i = \{0, 1, 2, ...p_x, p_y - 1\}$$

The helically interleaved phase factors are combined with different sets of IFFT transformed signal. Helical interleaver reduces the similarity among the phase factors thus decreases the PAPR of SCFDMA system.

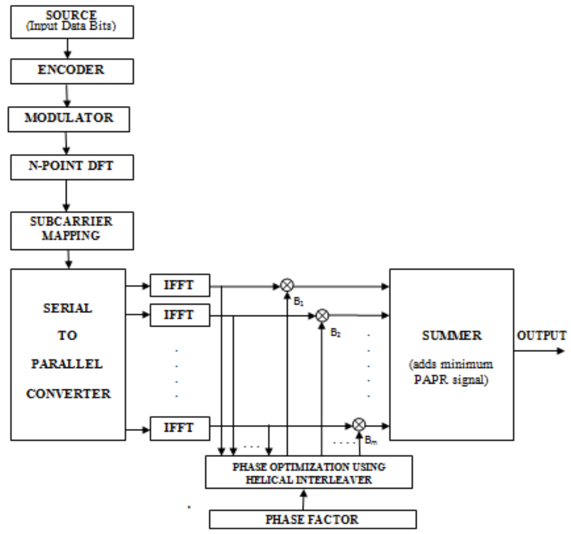

Fig. 3: Block Diagram of SCFDMA system with Helical Interleaver in PTS Technique

The Figure 3, represents the block diagram of proposed work. In the block diagram except the phase combination part of PTS technique other things are same as conventional SCFDMA with PTS technique. In PTS technique, after obtaining the different combinations of phases, the phase factors are helically interleaved to reduce the similarity among the occurrence of phase factor among the combinations. This process in turn reduces the similarity among the subcarriers which directly reduces the PAPR problem. Thus, the proposed work efficiently reduces the PAPR using the helical interleaver.

V. SIMULATION RESULTS AND ANALYSIS

The proposed work and its analysis have been carried out using MATLAB software. The proposed method of helical interleaver involved in PTS technique with SCFDMA system is simulated using following parameters,

TABLE 1: SIMULATION PARAMETERS

Simulation parameters	**Type/ Value**
Coding	Convolution Coding
Modulation	QPSK
Number of DFT points	64
Number of Subcarriers	128
Bandwidth Allocation Factor (Q)	2
Subcarrier Mapping Scheme	IFDMA
Number of Phase Factors	4
Phase Factors	1, -1, i, -i
Number of Phase Factor Combinations	16

The CCDF versus PAPR is simulated using MATLAB for the proposed scheme using the above mentioned simulation parameters.

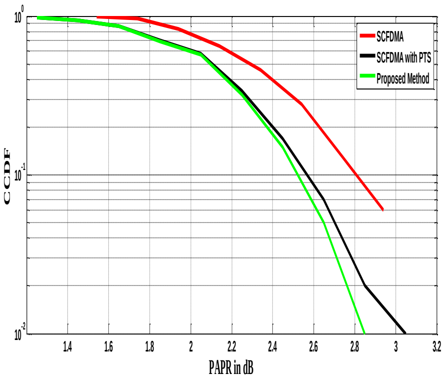

Fig. 4: CCDF Vs PAPR Performance of SCFDMA System with Helical Interleaver in PTS Technique

The figure 4 shows the CCDF performance of proposed method. At CCDF 10^{-1}, the PAPR value of conventional SCFDMA method is 2.74dB, SCFDMA with PTS method is 2.51dB and for proposed method is 2.44dB. From the numerical analysis, the proposed method shows approximately 3% reduction in PAPR compared to SCFDMA with PTS technique. The proposed system shows approximately 11% reduction in PAPR compared to conventional PAPR scheme.

VI. Conclusion

This paper mainly emphasis on reduction of PAPR in SCFDMA system. The PAPR reduction is done with the help of PTS technique in which helical interleaver is immersed in the phase combination process. The proposed method benefits by 3% reduction in PAPR compared to conventional SCFDMA with PTS technique and 11% reduction in PAPR compared to conventional SCFDMA system. The computational complexity of the system increases due to the addition of helical interleaving process. Therefore, further modification to the proposed work can be made in the reduction of computational complexity of the system.

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