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Efficient PAPR Reduction of OFDM by Hybrid Combination of Shifting Null subcarriers and Partial Transmit Sequence Method

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Abstract: *orthogonal frequency division multiplexing (OFDM) technique is a widely popular and attractive scheme for high-data-rate transmission because it can cope with frequency-selective fading channel. The modulators and demodulators of OFDM systems can be simply implemented by employing inverse fast Fourier transform (IFFT) and FFT to make the overall system efficient and effective Input signal will be modulated using modulator block and then this modulated signal will be given to null-data subcarrier shifting block. The shifting block will shift the null and data subcarriers and will find the data subcarriers will are when switched with null subcarriers provides lowest PAPR value. Once the shifted sequence providing lowest PAPR value is found, then PTS method will be applied to further reduce the PAPR value of OFDM system. In this way, shifting and PTS method will be combined to propose a new method to reduce the PAPR value of OFDM system. At receiver side, reverse operation will happen.*

Keywords: *OFDM, CDMA, Wireless Communication, Mobile Communication.*

1. INTRODUCTION

The Orthogonal frequency division multiplexing (OFDM) is a multicarrier communication system. It is a special case of multicarrier transmission technology, where a single data stream is transmitted over a number of lower rate subcarriers instead of single carrier system. But OFDM has one disadvantage of high PAPR value. To provide solution to this problem of high PAPR, new algorithm is proposed. In this work, OFDM system will be implemented with low Peak to Average Power Ratio (PAPR) value[1]. Input signal will be modulated using modulator block and then this modulated signal will be given to null-data subcarrier shifting block. The shifting block will shift the null and data subcarriers and will find the data subcarriers will are when switched with null subcarriers provides lowest PAPR value. Once the shifted sequence providing lowest PAPR value is found, then PTS method will be applied to further reduce the PAPR value of OFDM system. In this way, shifting and PTS method will be combined to propose a new method to reduce the PAPR value of OFDM system. At receiver side, reverse operation will happen [2].

2. LITERATURE REVIEW

OFDM is a special case of multi carrier transmission, where a single data stream is transmitted over a number of lower rate subcarriers. In single carrier system, if signal gets faded or interfered, then entire link gets failed, where as in a multicarrier system, only a small percentage of the subcarriers will be affected [13].

Most of the research is focused on the high efficient multicarrier transmission scheme based on "Orthogonal frequency" carriers. These carriers were mainly analog and generated using carrier bank, which was made up of the oscillators. The analog approach was very tough and it was not possible to have more number of subcarriers. It was also placing limitation on receiver design. This problem was solved by Weinstein and Ebert.

In 1971, Weinstein and Ebert applied the Discrete Fourier Transform(DFT) to parallel data transmission systems as part of modulation and demodulation process and presented their work as, "Data transmission by Frequency Division Multiplexing using the DFT".[11]

In addition to elimination of the banks of sub carrier oscillators and coherent demodulators usually required in FDM systems, this paper helped in understanding the digital implementation of OFDM system on a special purpose computer performing the FFT. Initially, OFDM was studied for high speed modem, digital mobile communications and high density recording. One of the systems realized the

OFDM techniques for multiplexed QAM using DFT and this work was presented as "An Orthogonally multiplexed QAM system using DFT", by BotaroHirosaki. In the 1990s, OFDM was exploited for wideband data communications over mobile radio FM channels, high bit rate DSL (HDSL, 1.6 Mbps), asymmetric digital subscriber lines (ADSL, up to 6 Mbps), digital audio broadcasting (DAB) [14].

The PAPR issue and its remedies are discussed in many papers. Lot of basic and modern information is available on internet and IEEE database. PAPR reduction in OFDM by shifting null and data subcarriers is suggested as, "OFDM PAPR Reduction by Shifting Null Subcarriers Among Data Subcarriers", by Bo Wang, Pin-Han Ho, and Chih-Hao Lin [1]. New version of PTS method is provided as, "Partial Transmit Sequence Scheme with New Phase Sequence for PAPR Reduction in OFDM Systems" by Pooria Varahram, BorhanuddinMohd Ali [3]. These papers explain the new PAPR reduction techniques, which reduces the PAPR of OFDM system with many other advantages.

The basic concept of OFDM, its limitations and its implementation is discussed in many books. A book by R. Van Nee, R. Prasad, "OFDM for wireless Multimedia Communication" and publication by Artech House is referred for basic concepts [10]. The use of IFFT and FFT in OFDM is justified and proved in this book mathematically. Key terms like number of subcarriers, modulation technique, guard band, cyclic prefix, zero padding etc are discussed in this book. A book by Yong SooChoo, Jaekwon Kim, Won Young Yang and Chung-Gu Kang, "MIMO-OFDM Wireless Communication with MATLAB" and publication by Wiley is referred for implementing the OFDM system on Mat lab software [6]. OFDM theory and its implementation is explained in this book, each step required for implementing OFDM system in Mat lab is also discussed.

3. RELEVANCE/MOTIVATION

Different theoretic and hypotheses on determination of PAPR distribution have been reported and various schemes exist to reduce the PAPR. Various schemes could be categorized into "signal distortion" schemes or "signal scrambling" schemes [3,10]. These techniques achieve PAPR reduction at the expense of increase in transmit signal power, increase in BER, increase in data rate loss, increase in computational complexity, distortion, channel side information etc.

The "signal distortion" schemes reduce high peaks by distorting the signal prior to amplification. Specific approaches include amplitude clipping, filtering, and companding. However "signal distortion" schemes could cause large in-band and out-of-band noise, resulting in system performance degradation[5].

The signal scrambling techniques scramble each OFDM symbol with different scrambling sequences for the PAPR reduction. Specific approaches includes partial transmit sequence(PTS) and PTS using adaptive nonlinear estimator, selective mapping(SLM), interleaving, active constellation extension, tone reservation (TR), tone injection(TI).

3.1 Clipping, filtering and peak window:

Power amplifier at transmitter, with saturation level below the signal span, automatically causes the signal to be clipped. Receiver needs to estimate two parameters of the transmitters clipping operation: location and size, which are difficult to get. However, clipping introduces both in-band distortion like self-interference and out-of-band radiation like nonlinear distortion into OFDM signals, which degrades systems BER and spectral efficiency .

3.2 Interleaving technique:

In interleaving approach, a set of interleavers is used to reduce the PAPR of multicarrier signal. An interleaver is a device that reorders data blocks. To make a set of modified data blocks, different interleavers are used to permute data blocks from the original data block[11]. The modified data block with the lowest PAPR is then chosen for transmission. To recover the original data block, the receiver only needs to know which interleaver is used at the transmitter.

3.3 Selected Mapping (SLM):

In the SLM technique, the transmitter generates a set of sufficiently different candidate data blocks by multiplying the same number of different phase sequences, all representing the same information as the original data block[4]. The one with the lowest PAPR is selected for transmission. Information about the selected phase sequence should be transmitted to the receiver as side information. Differentially encoded modulation may be applied before the IDFT and right after generating the alternative OFDM symbols. At the receiver, differential demodulation has to be implemented right after the DFT [12].

3.4 Tone Reservation (TR):

TR method has also been proposed for PAPR reduction. The main idea of this method is to keep a small set of tones for PAPR reduction. This can be originated as a convex problem and it can be solved accurately [6]. The amount of PAPR reduction depends on many factors such as number of reserved tones, location of the reserved tones, amount of complexity and allowed power on reserved tones etc.

3.5 Partial Transmit Sequence (PTS):

The transmitter constructs its transmitting signal with low PAPR, by scrambling appropriate rotation factors to subcarrier sub blocks. The difference between

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SLM and PTS is that the SLM applies independent scrambling rotations to all subcarriers, while the PTS only applies scrambling rotations to subcarrier sub blocks [8].

4. NEW PROPOSED SCHEME

In this method, innermost null subcarriers are used for PAPR reduction. Innermost null subcarriers are shifted with data subcarriers and then for each shifting, input to IFFT operator will change and hence its output will change and therefore this results in different PAPR value for each shifting[9,1].

This method finds the data subcarriers which are when shifted with null subcarrier provide the minimum PAPR value. This shifted combination of null-data subcarrier is used for transmission of OFDM symbol.

5. CONCLUSIONS AND FUTURE WORK

In this paper, we review the proposed method which is combination of shifting null subcarrier among data carrier and PTS (partial transmit sequence) reduces PAPR at great extent.

Future work is to reduce computational complexity.

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