REDUCING PAPR USING PTS TECHNIQUE HAVING STANDARD ARRAY IN OFDM

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Abstract:

Orthogonal frequency division multiplexing is an attractive technique for modern wireless communication and has recently been focused in high-data-rate wireless communication research. However, high peak-to-average power ratio (PAPR) of the transmitted signal is a major disadvantage of OFDM. So far, numerous approaches have focused on the PAPR reduction. As one of these approaches, partial transmit sequence is effective and uncomplicated. This paper presents a standard PTS architecture for PAPR reduction of OFDM Signals by using the standard arrays Partial Transmit Sequences. The PTS method divides the input data block into disjoint sub blocks and recombines them by using weighting factors. Furthermore, such PAPR solutions are analyzed theoretically and compared.

Keywords: OFDM; PAPR; PTS.

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I. INTRODUCTION:

Frequency division multiplexing (FDM) extends the concept of single carrier modulation by using multiple subcarriers within the same single channel. The total data rate to be sent in the channel is divided between the various subcarriers. If the FDM system above had been able to use a set of subcarriers that were orthogonal to each other, a higher level of spectral efficiency could have been achieved. The guard bands that were necessary to allow individual demodulation of subcarriers in an FDM system would no longer be necessary. The use of orthogonal subcarriers would allow the subcarriers' spectra to overlap, thus increasing the spectral efficiency. As long as orthogonality is maintained, it is still possible to recover the individual subcarriers signals despite their overlapping spectrums. OFDM has several properties which make it an attractive modulation scheme for high speed transmission links. One major difficulty about OFDM is its large peak-to-average (PAP) ratio which distorts the signal if the transmitter contains nonlinear components such as power amplifiers (PAs). The nonlinear effects on the transmitted OFDM symbols are spectral spreading, intermodulation, and changing the signal constellation. Therefore the PAs requires a back off which is approximately equal to the PAPR for distortion less transmission. This decreases the efficiency for amplifiers. Therefore, reducing the PAPR is of practical interest. OFDM is a block modulation scheme where a block of information symbols is transmitted in parallel on sub-carriers. Initially the input data samples are mapped onto phase shift keying (PSK) or quadrature amplitude modulation (QAM), and then using IFFT at the transmitter side and FFT at receiver, they will convert to time domain and frequency domain respectively. As shown in Fig. 1.1, IFFT is used to produce orthogonal data subcarriers. The complex baseband OFDM signal x in one symbol period can be represented by [2]

$$x_i = IFFT\{X\} = \frac{1}{N}\sum_{k=0}^{N-1} X_k e^{j2\pi ik/N} \qquad (1.1)$$

where $j = \sqrt{-1}$.

The PAPR of the transmitted OFDM signal can be defined in [3]. The peak to average power ratio for a signal x is defined as

$$PAPR = \frac{\max |x_i|^2}{E\{|x_i|^2\}} \qquad (1.2)$$

Expressing in decibels,

$$PAPR_{dB} = 10\log_{10}(PAPR)$$

Where E[lxil] is the average power of signal and it can be computed in the frequency domain because Inverse Fast Fourier Transform (IFFT) is a (scaled) unitary transformation. The PAPR of the discrete time sequences typically determines the complexity of the digital circuitry in terms of the number of bits necessary to achieve a desired signal to quantization noise for both the digital operation and the DAC. However, we are often more concerned with reducing the PAPR of the continuous-time signals in practice, since the cost and power dissipation of the analog components often dominate. To better approximate the PAPR of continuous-time OFDM signals, the OFDM signals Samples are obtained by L times oversampling. L-times oversampled time-domain samples are LN-point IFFT of the data block with zero-padding.

$$x_i = \frac{1}{N}\sum_{k=0}^{N-1} X_k e^{j2\pi nk/LN}, 0 \le n \le LN-1 \qquad (1.3)$$

Therefore, the over-sampled IFFT output can be expressed. However, the PAPR does not increase significantly after L=4. It has shown that L>=4 is sufficient to get accurate PAPR results [4]. PAPR is a random variable because it is a function of the input data, and the input data are random variable. Therefore PAPR can be calculated by using level crossing rate theorem that calculates the average number of times that the envelope of a signal crosses a given level. Knowing the amplitude distribution of the OFDM output signals, it is easy to compute the probability that the instantaneous amplitude will be above a given threshold and the same goes for power.

This is performed by calculating the complementary cumulative distribution function (CCDF) for different PAPR values as follows:

CCDF = Pr (PAPR > PAPR0)

$$P(PAPR > z) = 1-(1-e^{-z})^N \qquad (1.4)$$

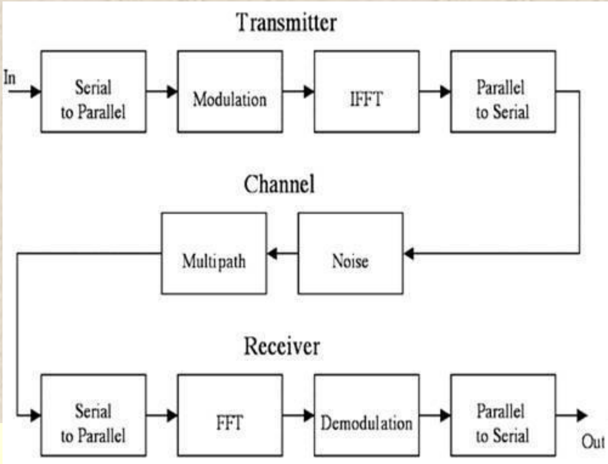

Fig.1.1: Block Diagram of OFDM System

II. RELATED WORK:

Many techniques have been proposed to reduce the PAPR, and a comprehensive review can be found in [1, 2, 3, 8]. Clipping scheme [7] is covered in signal distortion technique i.e. parts of signal is clipped that are outside the allowed region to reduce the PAPR. Coding schemes [4, 14, 15] are also used but these have drawbacks of using special decoders in receiver side. In SLM technique [1, 2], input data sequence are multiplied by each of the phase sequences to generate alternative input symbol sequence. Each of these alternative input data sequence is made the IFFT operations, and then the one with the lowest PAPR is selected for transmission. Among the techniques, the partial transmit sequence (PTS) [5, 10, 12, 13] is one of the effective methods, where the OFDM subcarriers are partitioned into several subgroups and each group of subcarriers is multiplied by a phase factor to reduce the PAPR. The block diagram of PTS is shown in Fig. 3.1. For PTS scheme, the known sub block partitioning methods can be classified into three categories [6]: adjacent partition, interleaved partition and random partition. Then, the sub-blocks are transformed into time-domain partial transmit sequences using ifft functions to each sub block.

III. SYSTEM DESIGN AND IMPLEMENTATION:

In a typical OFDM system with PTS approach to reduce the PAPR, the input data block in X is partitioned into M disjoint sub blocks, which are represented by the vectors $\{X^{(m)}, m=0,1,2,\ldots M-1\}$.

$$X = \sum_{m=0}^{M-1} X^{(m)} \qquad (3.1)$$

In general, for PTS scheme, the known sub block partitioning methods can be classified into three categories [6]: adjacent partition, interleaved partition and random partition. Then, the sub blocks are transformed into time-domain partial transmit sequences

$$x^{(m)} = [x_0^{(m)} x_1^{(m)} \ldots\ldots x_{LN-1}^{(m)}] = IFFT_{LN\times N}[X^{(m)}] \quad (3.2)$$

These partial sequences are independently rotated by standard phase factors b. The objective is to optimally combine the sub- blocks to obtain the time domain OFDM signals with the lowest PAPR.

$$\tilde{x} = \sum_{m=0}^{M-1} b_m x^{(m)} \qquad (3.3)$$

As a PAPR reduction technique, Partial Transmit Sequence (PTS), each sub-block is calculated by IFFT of size N (not N/M), while treating all other subcarriers as zero. The bock diagram is also shown in Fig 3.1 below.

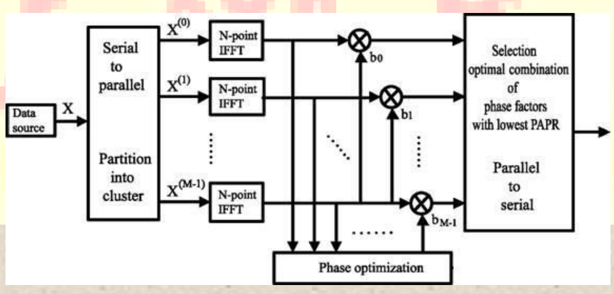

Fig. 3.1: Block Diagram of PTS

The selection of a best PAPR is performed after M parallel IFFTs, by weighting M Partial Transmit Sequences with M phase factors and adding them together. Parallel calculation of

IFFTs means there is no sacrifice of system speed. The optimization of the phase factors is performed after all IFFT operations. So there is no need to repeat IFFT calculations, as required by many other PAPR reduction techniques. Each carrier in the sub blocks X(v) is multiplied with the same rotation factor Rd. Finally, the time domain vector with the lowest PAPR is transmitted. In the figure, Rd is chosen {±1, ±j}. With increasing the number of sub-blocks V, the probability of high PAPR decreases obviously, compared to the original OFDM signal.

IV. PERFORMANCE ANALYSIS:

The complementary cumulative distribution function (ccdf) is defined as the probability that the PAPR value is larger than a specific value PAPR0, is generally used to evaluate the PAPR reduction performance for different schemes. To evaluate and compare the performance of the Partial Transmit Sequence with the original PAPR reduction technique, computer simulation has been performed in which PTS and original PAPR are explained for which standard arrays are used for phase shifting in the technique. Fig. 4.1 shows the ccdf of the PAPR.

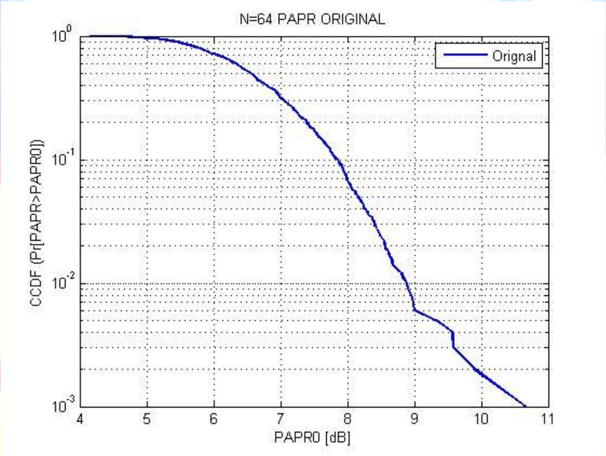

Fig. 4.1: Complementary cumulative distribution function for theoretical PAPR

A few input symbols are selected by using standard array for phase rotation. This scheme has the advantage of not increasing the input power.

Table 1: Parameters of simulation

Number of subcarrier	64
Modulation type	QPSK
Number of simulated Bits	Over 1MBits

The parameters of simulations are shown in Table 1. These related schemes are effective and flexible to reduce the PAPR without nonlinear distortion.

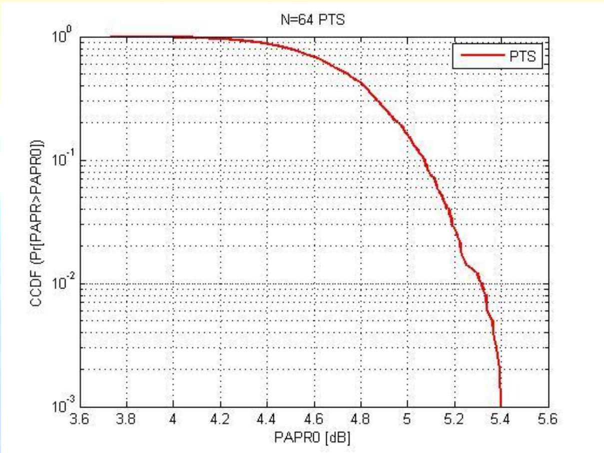

Fig 4.2: Complementary cumulative distribution function of PTS

Each of these alternative input data sequence is made the IFFT operations, and then the one with the lowest PAPR is selected for transmission. The simulation results are shown in Fig 4.2.

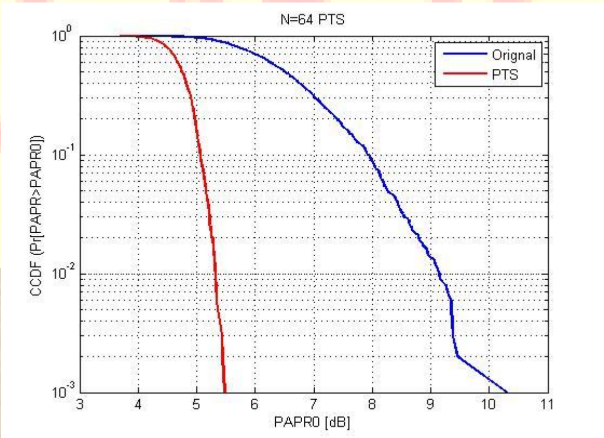

Fig 4.3: Comparison of ccdf Function of symbols PAPR

The overall comparison of complementary cumulative distribution function of PTS with the original is depicted in Fig 4.3.

V. CONCLUSION & FUTURE SCOPE:

Partial Transmit Sequence using standard array is used to reduce the PAPR in OFDM systems. A few input symbols are selected by using standard array for phase rotation. This scheme has the advantage of not increasing the input power. Simulation results show that the Partial Transmit Sequence has peak power reduction capability than ordinary OFDM system and SLM. PTS and SLM scheme have shown the PAPR=5.30 dB and 6.2 dB at the probability of 10^{-2} respectively.

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