

PAPR Reduction Technique : Partial Transmit Sequence (PTS)

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Abstract -Orthogonal Frequency Division Multiplexing (OFDM) is a very attractive technique for high-data-rate transmission in wireless and wired applications. One major drawback of OFDM is that the time domain OFDM signal which is a sum of several sinusoids leads to high peak to average power ratio (PAPR).OFDM faces the Peak-to-Average Power Ratio (PAPR) problem which leads to power inefficiency in RF section of the transmitter. Number of techniques has been proposed for reducing the PAPR in OFDM systems. In this paper PTS(Partial transmit sequence) technique proposed for reducing the PAPR.The partial transmit sequences (PTS) scheme achieves an excellent peak-to-average power ratio (PAPR) reduction performance of orthogonal frequency division multiplexing (OFDM) signals at the cost of exhaustively searching all possible rotation phase combinations, resulting in high computational complexity.

Key Words: Orthogonal frequency division multiplexing (OFDM), peak-to-average power ratio (PAPR), CCDF, partial transmit sequences, IFFT

1. INTRODUCTION

Orthogonal frequency division multiplexing (OFDM) is one of the most attractive technology for fourth generation (4G) wireless communication. The basic principle of OFDM is to split a high-rate data stream into a number of lower rate streams that are transmitted simultaneously over a number of subcarriers. OFDM faces several challenges. The key challenges are large peak to average ratio due to non linearity's of amplifier; phase noise problems of oscillator, need frequency offset correction in the receiver. Large peak-to-average power (PAP) ratio which distorts the signal if the transmitter contains nonlinear components such as power amplifiers (PAs).This is because power amplifier at transmitter enters into saturation region instead of being in linear region which causes distortion to the transmitted signal which further results in increased BER at the receiver. In other words, the nonlinear distortion causes both in-band and out-of-band interference to signals. 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. Many PAPR reduction methods have been proposed. The associated drawback is the increased power and implementation complexity. OFDM is adopted

in various communication applications such as, digital video broadcasting (DVB), digital audio broadcasting (DAB) and wireless local area networks (WLAN). As a result, high PAPR of transmitted signals causes nonlinear distortion at high power amplifier (HPA) and reduces its power efficiency. Also, a distortion of the signal leads to degradation of adjacent channel interference and high bit error rate (BER). To avoid the appearance of large PAPR of OFDM signals, different methods for PAPR reduction have been proposed. In this paper, we discuss the PTS technique for PAPR reduction. Among all existing methods, the partial transmit sequence (PTS) is an attractive solution due to its good performance of PAPR reduction In the PTS method, input data symbols are divided into disjointed sub-blocks and the sub-blocks are separately phase-rotated by individually selected phase factors through the process of improving performance of the PAPR. The remainder of this paper is organized as follows. In section 3, some basics about PAPR problem in OFDM is given. Section 4 describes CCDF of OFDM. Section 5 describes Partial Transmit Sequence (PTS) Technique. In Section 6 describe simulation Results. Conclusions is given in section 7.

2.OFDM SYSTEM

The transmit signal can be generated by a simple IDFT operation, and at the receiver; a DFT can be performed to recover the transmitted signal. In OFDM systems, a fixed number of successive input data samples are modulated first and then jointly correlated together using IFFT at the transmitter side. IFFT is used to produce orthogonal data subcarriers. Mathematically, IFFT combines all the input signals to produce each signal of the output OFDM symbol.

The OFDM signal x_n is obtained by considering data block x_n of N symbols each, where $n = [1, 2, \dots, N-1]$ and each symbol is modulated by a subcarrier which is taken from a set of subcarriers, and these subcarriers are chosen such that they are orthogonal to each other. The discrete time domain signal of OFDM is generated by applying N-point IFFT on frequency domain OFDM signal X_k , which can be written as:

$$x_n = \frac{1}{\sqrt{N}} \sum_{k=0}^{N-1} X_k e^{j2\pi k \frac{n}{N}}, 0 \leq n \leq N-1,$$

Where X_k is modulated symbol

3. PEAK TO AVERAGE POWER RATIO

OFDM has become a popular technique in various high-speed wireless data transmission systems. Due to the nature of the IFFT it sums N sinusoids through superposition; some combinations of the sinusoids create large peaks. The drawback of a large dynamic range is that it places pressure on the design of components such as the word length of the IFFT/FFT pair, DAC and ADC [5], mixer stages, and most importantly the HPA which must be designed to handle irregularly occurring large peaks. Failure to design components with a sufficiently large linear range results in saturation of the HPA. Saturation creates both in band distortion, increasing the BER and out of band distortion.

The PAPR (in dB) of the transmitted OFDM signal is defined as the ratio between the maximum instantaneous power and its average power, which can be written as,

$$PAPR = \frac{\text{The peak or maximum power of the signal } x(n)}{\text{The average power of the signal } x(n)}$$

$$= \frac{\max[|x(n)|^2]}{E[|x(n)|^2]}$$

Where E [.] denotes the average power.

4. CCDF of The PAPR

The complementary cumulative distribution function (CCDF) of the PAPR is the most frequently used performance measure for PAPR reduction techniques. A CCDF curve shows how much time the signal spends at or above a given power level. A CCDF curve is basically a plot of relative power levels versus probability. Mathematically CCDF can be explained with a set of data having the probability density function (PDF).

To obtain the Cumulative Distribution Function (CDF), the integral of the PDF is computed. Then inverting the CDF results in the CCDF. It concludes that the CCDF is the complement of the CDF or $CCDF = 1 - CDF$. CCDF measure the efficiency of any PAPR technique. The CCDF of the PAPR denotes the probability that the PAPR is below the threshold level $PAPR_0$, which can be expressed as,

$$CCDF = Pr (PAPR > PAPR_0)$$

5. Partial transmit technique

Partial Transmit Sequence (PTS) is one of the techniques used to reduce PAPR in OFDM system which is implemented in this paper. Main idea of PTS is data blocks are divided into non overlapping sub-block with independent rotation factor. This rotation factor generates time domain data with lowest amplitude. The fundamental idea of this technique is sub-dividing the original OFDM symbol data into sub-data which is transmitted through the sub-blocks which are then multiplied by the weighing value which were differed by the phase rotation factor until choosing the optimum value which has low PAPR.

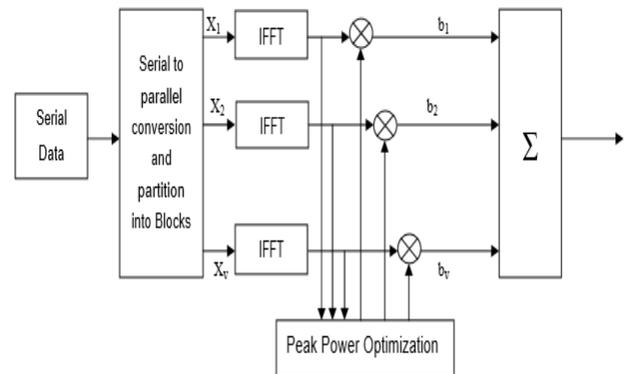


Fig -1: Block Diagram of PTS Technique

The block diagram for PTS technique implementation is shown in figure 2. The data sequence X in frequency domain is sub-divided into v sub-sequence which were transmitted in sub-blocks without overlapping and having equal size of N which contains N/V non-zero values in each sub-blocks. Thus Peak to average power ratio has been reduced in OFDM using partial transmit sequence. Main drawbacks of this technique are searching complexity increases exponentially with the number of sub blocks.

5.1. Mathematical Model For PTS Technique

In PTS approach, the frequency domain sequence which are represented by vectors $X_m, m = 1, 2, 3, \dots, M$ is partitioned into M disjoint sub block of equal size in X input data block, which can be represented as

$$X = \sum_{m=1}^M X_m$$

Where all the subcarrier positions that presented by another block are is set to zero, so that the sum of all the sub-blocks constitutes the original signal. Then, the sub-blocks X are transformed into time-domain partial transmit sequence by used Inverse Discrete Fourier Transform operation, which can expressed as

$$x_m = \sum_{m=1}^M IDFT \{X_m\}$$

Each sub-block x is multiplied by phase factors and combined together to create a set of candidates. The candidate with the lowest PAPR is chosen for transmission. After combination, the time domain signal is given by

$$x = \sum_{m=1}^M b_m x_m$$

6. SIMULATION RESULTS

In this section, the simulation result has been done to get the performance of Partial transmit sequence technique (PTS). In this section, first we get the results of PAPR of OFDM with different subcarriers. There are the result for different subcarriers such as, N=64, 128, 256, 512, 1024. We can see the result; there is PAPR increase with

increase in subcarriers. The Partial transmit transmit technique to reduce PAPR for OFDM system is efficient technique. Finally, we get result of the performance PTS technique. The complementary cumulative distribution function (CCDF) of the PAPR is the most commonly used performance measures for PAPR reduction techniques.

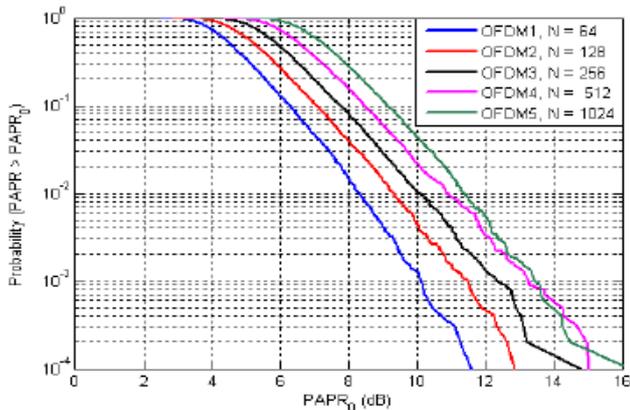


Fig -2:PAPR with Different Number of Carriers

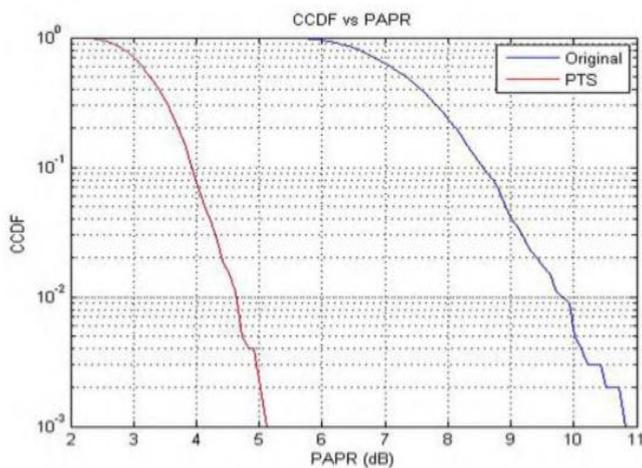


Fig -3: Comparison between PAPR of original OFDM and PTS technique [2]

Now, In Fig.3 result of comparison of PAPR of OFDM and PAPR of PTS technique. We get results for PAPR of original OFDM and PAPR of PTS technique. We can see using the PTS technique PAPR reduced compare to PAPR of original OFDM.

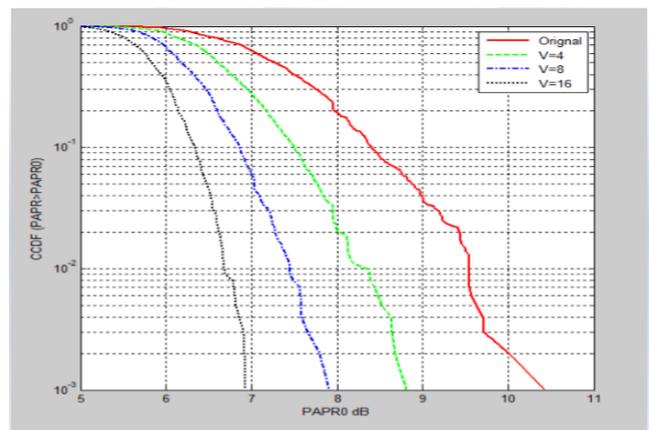


Fig -4:CCDF of PAPR of OFDM using PTS for various V [3]

In Fig.3 result of CCDF of PAPR of OFDM using PTS techniques as the number of sub-block V varies. It can be noted that PAPR performance improves as the number sub-blocks increases with V=4, 8 and 16.

7. CONCLUSION

The major difficulty in the practical implementation of the Orthogonal Frequency Division Multiplexing is its high PAPR. To transmit signals with large PAPR, expensive wide range power amplifiers are required. High PAPR results in reduction of efficiency of the Power Amplifier. In this paper partial transmit sequence (PTS) PAPR reduction technique are described. One of the effective methods of PAPR reduction is Partial Transmit Sequence scheme. We can see the using new phase sequence, we reduce complexity. The complexity of this scheme can be reduced by the application of a new phase sequence but the PAPR reduction is slightly reduced. So, In future we can improve the performance of PAPR reduction using Genetic Algorithm (GA).

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