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An Overview on PAPR Reduction in OFDM by PTS Technique

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Abstract—**In this paper, we propose a Peak-to-Average Power Ratio (PAPR) reduction technique using a partial transmit sequence (PTS) . This technique is used in a system based on Orthogonal Frequency Division Multiplexing (OFDM). In order to reduce PAPR, the sequence of input data is rearranged by the PTS for the reduction of PAPR. Owing to the high spectral efficiency and the immunity to multipath channels, this paper proposes a novel peak to average power ratio (PAPR) reduction scheme, OFDM is a promising technique for high-rate data transmission. But the high Peak-to-Average Power Ratio (PAPR) is one of the main obstacles to limit wide applications of OFDM. we propose a PAPR (peak to average power ratio) reduction method using Partial Transmit Sequences (PTS) Technique to lower the high PAPR of OFDM system as compared to other techniques. The merit of this proposed method is efficient PAPR reduction performance.**

Key Words — **Orthogonal frequency-division multiplexing (OFDM), peak-to-average power ratio (PAPR), partial transmit sequence (PTS), selected mapping (SLM), complementary cumulative distribution function (CCDF).**

I. INTRODUCTION

Orthogonal Frequency Division Multiplexing (OFDM) has recently been widely adopted in various wireless communication standards, Orthogonal Frequency Division Multiplexing (OFDM) is an attractive multicarrier technique for high-bit-rate transmission. In OFDM system, data is transmitted simultaneously through multiple frequency bands. It is robust to frequency selective fading and narrow band interference. So, OFDM has been adopted as wireless communication. However it is susceptible to high peak-to-average power due to an unstable envelope. This, in turn, leads to poor power efficiency. Furthermore, when it passes through nonlinear device such as HPA, high peak signals may be clipped. The distortions caused by this clipping effect will affect orthogonality of sub-carriers. In addition to this, large PAPR also demands ADCs (Analog-to-Digital Converters) with large dynamic range, OFDM has many well known advantages such as robustness against frequency selective fading or narrowband interference, high bandwidth efficiency and efficient implementation. Recently, OFDM is mainly used in digital audio broadcasting (DAB), digital video broadcasting-terrestrial (DVB-T), and mobile multimedia access communication (MMAC).

In order to reduce the PAPR of an OFDM signal, many techniques are proposed, which can be organized into three classes: signal distortion, block coding, and signal scrambling. The simplest class of techniques to reduce the PAPR is signal distortion, including clipping and peak windows, To clip the signal, the peak amplitude is limited to some desired maximum level. It can give a good PAPR. But the BER performance becomes very worse due to many defected signals. Another method for PAPR reduction is based on the use of coding schemes, where the original data sequence is mapped onto a longer sequence with a lower PAPR in the corresponding OFDM signal. Basically, a coding scheme would involve a large look-up table and is more suitable for those OFDM systems with a small number of sub carriers. Signal scrambling includes SLM, DSI and PTS techniques. SLM. may be classified into the phase control scheme to escape the high peak. One signal of the lowest PAPR is selected in a set of several signals containing the same information data. Both techniques require much system complexity and computational burden by using of many IDFT block.

However, this is very flexible scheme and has an effective performance of the PAPR reduction without any signal distortion. In DSI, each different dummy sequences are added into the same input data, and after IDFT, the signal has a minimum PAPR is selected for output signal . This method also requires much system complexity computational burden. However, the side information is not necessary because inserted dummy sequence is not used for data demodulation in the receiver.In this paper, an effective scheme is proposed, which constructs a favorable OFDM transmit signal with reduced PAPR in section . Partial Transmit Sequences (PTS) Technique is described in section [3] and for different number of phase sequences and variable block sizes are presented in this section.

II. General Structure Of OFDM And Distribution Of PAPR

The basic principle of OFDM is to split a high rate input data stream into a number of lower rate streams that are transmitted simultaneously over a number of subcarriers. Because the transmission rate is slower in parallel subcarriers, a frequency selective channel appears to be flat to each subcarrier. ISI is eliminated almost completely by adding a guard interval at the beginning of each OFDM symbol. However, instead of using an empty guard time, this interval is filled with a cyclically extended version of the OFDM signal.

Let us denote the collection of all data symbols X[k],
k = 0, 1, …, N – 1, as a vector $X = [X_0, X_1, ..., X_{N-1}]^T$ that will be termed a data block. The complex base band representation of a multicarrier signal consisting of N sub carriers is given by

$$x(t) = \frac{1}{\sqrt{N}}\sum_{k=0}^{N-1} X(K)e^{j2\pi\Delta f kt/T} \quad , \quad t \in [0,T]$$

where $j = \sqrt{-1}$, Δf is the sub carrier spacing, and NT denotes the useful data block period.
In OFDM the sub carriers are chosen to be orthogonal (i.e. $\Delta f = 1/NT$). The PAPR of the transmit signal is defined as

$$PAPR = \frac{Peak\ power\ of\ signal}{Average\ power\ of\ the\ signal}$$

$$PAPR = \frac{\max |x|^2}{E[|x|^2}$$

In particular, a base band OFDM signal with N sub channels has $PAPR_{max} = 10\log_{10} N$. From the central limit theorem, it follows that for large values of N, the real and imaginary values of x(t) become Gaussian distributed. Therefore the amplitude of the OFDM signal has a Rayleigh distribution, with a cumulative distribution given by $F(z)= (1- e^{-z})$ .The probability that the PAPR is below some threshold level can be written as $P(PAPR \leq z) =(1-e^{-z})^N$. In fact, the complementary cumulative distribution function of PAPR of an OFDM is usually used, and can be expressed as

$$P(PAPR > z) = 1-(1- e^{-z})^N.$$

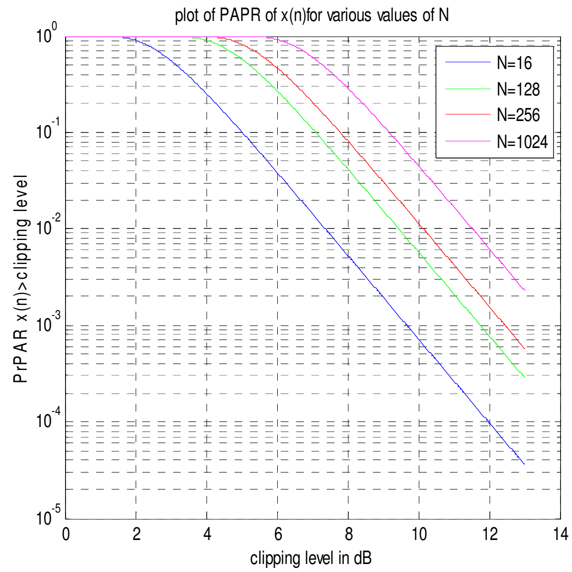

Fig 1. Plot of CCDF of PAPR for various values of N.

The CCDFs are usually compared in a graph such as Fig. 1, which shows the CCDFs of the PAPR of an OFDM signal with 256 and 1024 sub carriers (*N* =16,128, 256,1024) for quaternary phase shift keying (QPSK) modulation. The horizontal and vertical axes represent the threshold for the PAPR and the probability that the PAPR of a data block exceeds the threshold, respectively. It is shown that the unmodified OFDM signal has a PAPR that exceeds 10 dB for less than 1 percent of the data blocks for N = 256. With a certain PAPR value, the occurrence probability of OFDM signals which exceed this value augment, as the number N increases.

III. Proposed PAPR Reduction Method (PTS)

There are a number of techniques to deal with the problem of PAPR. Some of them are amplitude clipping and filtering, partial transmit sequence (PTS),selected mapping (SLM).These techniques achieve PAPR reduction at the expense of transmit signal power increase, bit error rate (BER) increase, data rate loss, computational complexity increase, and so on.

A. Amplitude Clipping And Filtering

A threshold value of the amplitude is set in this process and any sub-carrier having amplitude more than that value is clipped or that sub-carrier is filtered to bring out a lower PAPR value. The Clipping based techniques clips the time domain signal to predefined level.The method of Clipping and Filtering can be described with three modulation techniques, Quadrature Phase Shift Keying (QPSK) Quadrature Amplitude Modulation (QAM) and Pulse Amplitude Modulation (PAM). The OFDM signal contains high peaks so it is transferred from the clipping method.

B. Selected Mapping

In this a set of sufficiently different data blocks representing the information same as the original data blocks are selected. Selection of data blocks with low PAPR value makes it suitable for transmission. The input data sequences are multiplied by each of the phase sequences to generate alternative input symbols sequences. Each of these alternative input data sequence is made the IDFT operation, and then the one with the lowest PAPR is selected for transmission.

C. Partial Transmit Sequence

Transmitting only part of data of varying sub-carrier which covers all the information to be sent in the signal as a whole is called Partial Transmit Sequence Technique.

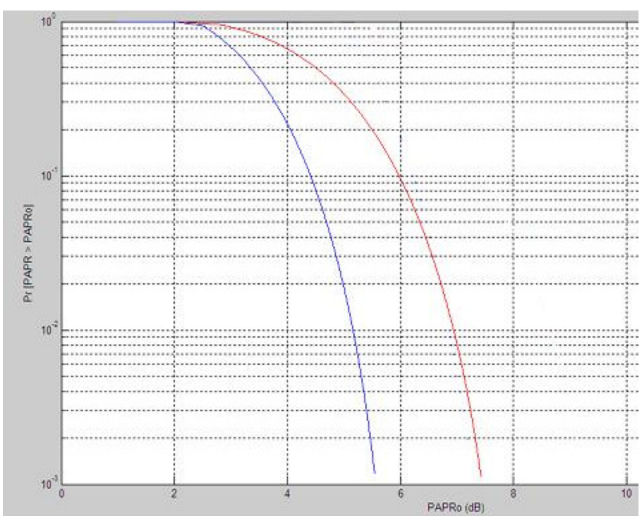

Fig 2. Performance Curves of SLM and PTS Techniques.

Among the three techniques that we took up for study, we found out that Amplitude Clipping and Filtering results in Data Loss, whereas, Selected Mapping (SLM) and Partial Transmit Sequence (PTS) do not affect the data. From the comparison curve of the SLM and PTS techniques.

In PTS technique, an input data block of N symbols is partitioned into disjoint sub blocks. The sub carriers in each sub block are weighted by a phase factor for that sub block. The phase factors are selected such that the PAPR of the signal is minimized.

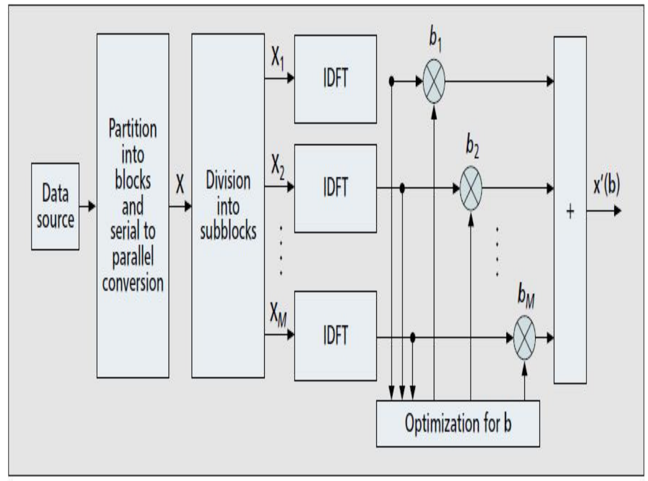

Fig 3. A block diagram of the PTS technique.

In the PTS technique [9,10] input data block X is partitioned into V disjoint sub blocks **X**v = [Xv,$_0$, Xv,$_1$, …, Xv,$_{N-1}$], v = 1, 2, …, V. The sub blocks are combined to minimize the PAPR in the time domain. The set of phase factors is denoted as a vector b = [b_1, b_2, …, b_v]. The time domain signal after combining is given by

$$x'(b) = \sum b(v).x(v) \qquad 0 \leq v \leq V$$

$$x'(b) = [x'_0(b), x'_1(b). \ldots x'_{N-1}(b)]$$

The objective is to find the set of phase factors that minimizes the PAPR. Minimization of PAPR is related to the minimization of max [x' (b)].

In general, the selection of the phase factors is limited to a set with a finite number of elements to reduce the search complexity. The set of allowed phase factors is written as P = {0, 1, …, W – 1}, where W is the number of allowed phase factors. So, we should perform an exhaustive search for V phase factors. Hence, W^V sets of phase factors are searched to find the optimum set of phase factors. The search complexity increases exponentially with the number of sub blocks V. PTS needs V IDFT operations for each data block. The amount of PAPR reduction depends on the number of sub blocks V and the number of allowed phase factors W.

In PTS, the number of rotation factor {*b* (*v*)} may be limited in a certain range. W^V accessorial information sequences is required in PTS-OFDM, where V denotes the number of sub blocks and W denotes the number of the phase factors. PTS needs V IDFT operations for each data block and the redundant bits of side information are as follows: R= (V-1) $\log_2$ W. Note that PTS-OFDM with V=4 sub blocks and W= 4 phase factors for each, corresponds to a redundancy of 6 bit. PTS works with little additional redundancy and moderate transmitter complexity. But PTS performs better than others with the same number of sub blocks. The side information must be transmitted to the receiver to recover the original data block. One way to do this is to transmit these side information bits with a separate channel other than the data channel. It is also possible to include the side information within the data block; however, this results in data rate loss.

IV. RESULTS

The PAPR problem in OFDM is still an ongoing issue, especially for portable devices where the need to minimise the power amplifier linear range is paramount. the PTS methods developed in this paper to reduce the PAPR can be combined with these techniques to further reduce complexity and the peak power.

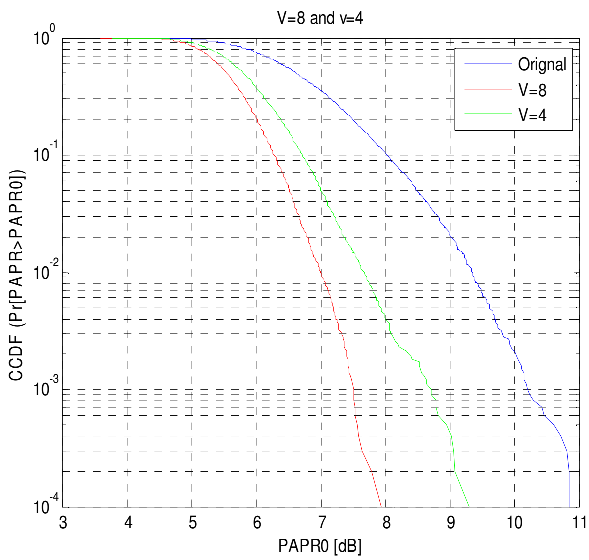

Fig 4. CCDF of PAPR by PTS for various V

The PAPR reduction process can be made more efficient by increasing the number of phase sequences and the number of sub blocks, although there may be a little bit increment of calculation complexity. the comparison of PAPR for original unmodified OFDM signal and by using PTS technique for different phase sequences and variation in number of sub blocks.

CONCLUSION

Among all the techniques of PAPR reduction in OFDM signals, the PAPR reduction in OFDM is efficiently done by partial transmit sequence (PTS) , we found out that Amplitude Clipping and Filtering results in Data Loss, whereas,in Selected Mapping (SLM) and Partial Transmit Sequence (PTS) do not affect the data. From the comparison curve of the SLM and PTS techniques,the efficient PAPR reduction performance is done by partial transmit sequence (PTS) .

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