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Comparison of Various Peak To Average Power Reduction Techniques

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Abstract
In this paper we study various peak to average power reduction techniques and find the advantages and disadvantages of these techniques.The main disadvantage is high PAPR in transmission for high-speed transmission due to its spectrum efficiency and channel robustness. OFDM signals are mostly responsible for the problem of PAPR

Keywords: High power amplifier (HPA), peak-to-average power ratio (PAPR)

1.Clipping and Filtering

Clipping too large peaks is a simple solution to the PAPR problem. Clipping belongs to the group of techniques that reduce large peaks by nonlinearly distorting the signal. It does not add extra information to the signal and too large peaks occur with low probability so the signal is seldom distorted [1]. The maximum peak power allowed is determined by the system specifications, usually by the linear region of the power amplifier. A maximum peak amplitude *A* is chosen so that the OFDM signal does not exceed the limits of this region, symbols that exceed this maximum amplitude, will be clipped

Where x_k^c is the clipped signal, x_k is the transmitted signal, is the clipping amplitude and $\phi(x_k)$ is the phase of the transmitted signal x_k. Clipping is a non linear process so it introduces in-band distortion, also called clipping noise, out of band radiation and inter-carrier interference shown in figure 1, which degrade the system performance and the spectral efficiency. Filtering can reduce out of band radiation after clipping although it cannot reduce in-band distortion. However, clipping may cause some peak re-growth so that the signal after clipping and filtering will exceed the clipping level at some points.

2.Partial Transmit Sequence (PTS)

This proposed method is based on the phase shifting of sub-blocks of data and multiplication of data structure by random vectors. This method is flexible and effective for OFDM system. The main purpose behind this method is that the input data frame is divided into non-overlapping sub blocks and each sub block is phase shifted by a constant factor to reduce PAPR.[2] In the PTS technique, an input data block of *N* symbols is partitioned into disjoint sub blocks. The subcarriers 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 combined signal is minimized. Figure 2 shows the block diagram of the PTS technique [4].

The ordinary PTS technique has exponentially increasing search complexity. To reduce the search complexity, various techniques have been suggested. In [3] iterations for updating the set of phase factors are stopped once the PAPR drops below a preset threshold. In [3-5] various methods to reduce the number of iterations are presented. These methods achieve significant reduction in search complexity with marginal PAPR performance degradation.

3. Selected Mapping (SLM)

In the SLM technique, the transmitter generates a set of sufficiently different candidate data blocks, all representing the same information as the original data block, and selects the most favourable for transmission. In the SLM, the input data structure is multiplied by random series and resultant series with the lowest PAPR is chosen for transmission. To allow the receiver to recover the original data to the multiplying sequence can be sent as 'side information'. The block diagram of SLM technique is shown in figure 3.

Each data block is multiplied by V different phase sequences, each of length N, $B_v = \left[b_{v,0}, b_{v,1}, \ldots\ldots, b_{v,N-1}\right]^T \quad (v = 0,1,\ldots.., V-1)$ resulting in V modified data blocks. Thus, the vth phase sequence after multiplied is $X^v = \left[X_0 b_{v,0}, X_1 b_{v,1}, \ldots\ldots, X_{N-1} b_{v,N-1}\right]^T (v = 0,1,\ldots..V-1)$

Among the data blocks $X^v (v = 0,1,\ldots\ldots, V-1)$, only one with the lowest PAPR is selected for transmission and the corresponding selected phase factors $b_{v,n}$ also should be transmitted to receiver as side information [6] [7].

4.Tone Reservation and Tone Injection

Tone reservation is an efficient technique to reduce the PAPR of a multicarrier signal. In an OFDM system tone means a "subcarrier". The basic idea is to reserve a small set of tones for the PAPR reduction signals. These reserved tones are not used for data transmission instead they are reserved for anti peak signals and they are orthogonal to the other tones which bear data. The fact behind the logic of TR is: There are some tones that have low SNR and therefore not able to carry data .So, these tones are used to construct a signal that can be used to reduce the PAPR of original multicarrier signal.

Let 'x'be original time domain signal that suffer from a problem of PAPR. The main goal of TR technique is to find a time domain signal 'c' which when add to the original signal 'x',the PAPR is reduced as shown in the Figure 4.

If 'X' and 'C' are the frequency domain signals of 'x' and 'c', and then it can be expressed as:

$$x + c = IDFT\left(X + C\right)$$

Here vectors 'X' and 'C' are designed in such a way that these two lie in disjoint frequency sub spaces. This can be further illustrated by supposing that 'R' tones are reserved for reducing PAPR. Let these 'R' tones be placed at $\{i_1, i_2, i_3, \dots i_R\}$ locations. Therefore the vectors' X' and 'C' are designed in such a way that

$$X_k = 0; \because k \in \{i_1, i_2, i_3, \dots i_R\}$$

And $$C_k = 0; \because k \notin \{i_1, i_2, i_3, \dots i_R\}$$

These 'R' tones are called Peak Reduction Tones (PRTs) or these 'R' non zero positions in 'C' are called Peak Reduction Carriers (PRCs). in a data block is with more mapping choices, it is likely to achieve better PAPR performance. The method is called tone injection because substituting a point in the original constellation for a new point in the expanded constellation is equivalent to add a tone carrying the information of the vector between the two points. The TI method may introduce a power increase in the transmit signal due to the injected signal [8].

5.Coding Technique

Coding techniques can be applied for signal scrambling, M sequences, Golay complementary sequences, Shapiro-Rudin sequences codes can be used to reduce the PAPR efficiently. A simple idea introduced in [9] is to select those code words that minimize or reduce the PAPR. Its basic idea is that mapping 3 bits data into 4 bits codeword by adding a Simple Odd Parity Code (SOBC) at the last bit across the channels. The main disadvantage of SOBC method is that it can reduce PAPR for a 4-bit codeword. The block coding techniques have three stages for the development. The first stage works with the collection of appropriate sets of code words for any number of carriers, any M-ary phase modulation method, and any coding rate. The second stage works with the collection of the sets of code words which enable proficient implementation of the encoding/decoding. The third stage offers error deduction and correction potential .These different methods are for the collection of the sets of code words. The mainly insignificant method, order to search the peak envelope power (PEP) for all possible code words for a certain length of given number of carriers.

6.Active Constellation Extension (ACE)

ACE is a similar PAPR reduction method to TI. In this method, some of the outer signal constellation points in a data block are allowed to move toward the outside of the original constellation. By using a QPSK signal constellation, all the four points are outer points and allowed to move toward the extended shaded regions as shown in figure 5 which represents the region of increased margin for the data symbol in the first quadrant[10]

If adjusted intelligently, a combination of these additional signals can be used to partially cancel time domain peaks in the transmit signal. Therefore, each symbol which is with more mapping choices make the possible PAPR reduction and increases

transmit signal power. The ACE method can also be applied to larger constellation size such as MPSK or MQAM because data points that lie on the outer boundaries of the constellations have room for increased margin without degrading the error probability for other data symbols. It is possible to combine the TR and ACE techniques to make the convergence of TR much faster.

7.Interleaving

In this approach, a set of inter leavers is used to reduce the PAPR of the multicarrier signal instead of a set of phase sequences. Interleaving technique is similar to SLM technique for PAPR reduction [11-13]. An inter leaver is a device that operates on a block of N symbols and reorders or permutes them. Thus, data block $X = [X_0, X_1, \ldots X_{N-1}]^T$ becomes $X' = [X_{\pi(0)}, X_{\pi(1)}, \ldots X_{\pi(N-1)}]^T$ where $\{n\} \leftrightarrow \{\pi(n)\}$ is a one-to-one mapping $\pi(n) \in \{0,1,\ldots,N-1\}$ and for all n. To make K modified data blocks, interleavers are used to produce permuted data blocks from the same data block.

RESULT:-

Comparative Study of PAPR reduction Techniques shown in table 1

CONCLUSION:-

The PAPR reduction technique should be carefully chosen according to various system requirements. Comparative study of all techniques has been reviewed by discussing advantages and disadvantages of various PAPR reduction techniques.

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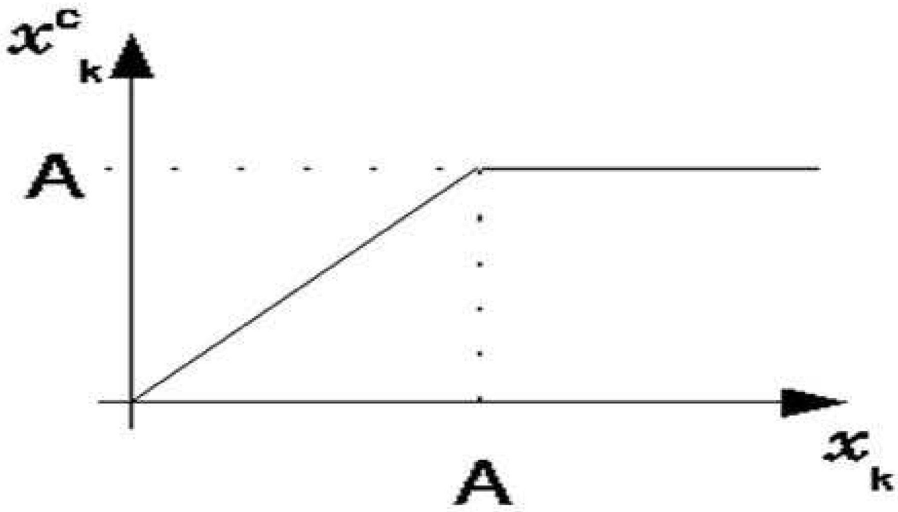

Figure 1 Cliping function

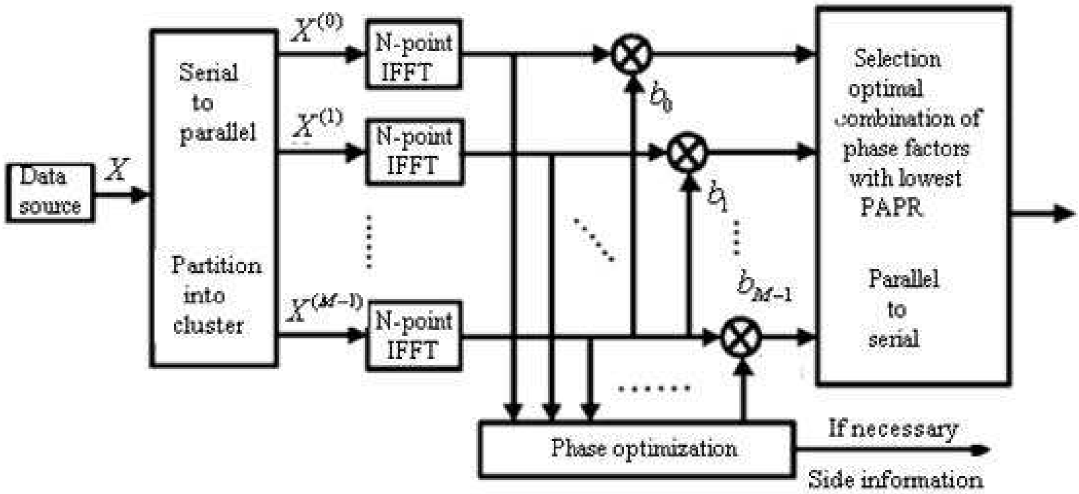

Figure 2 block diagram of pts technique

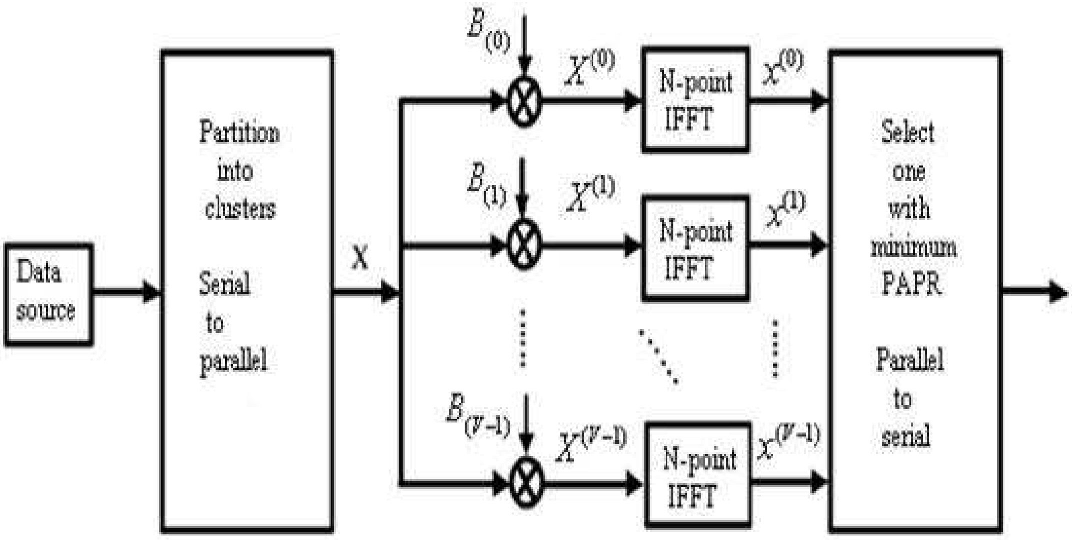

Figure 3 block diagram of slm technique

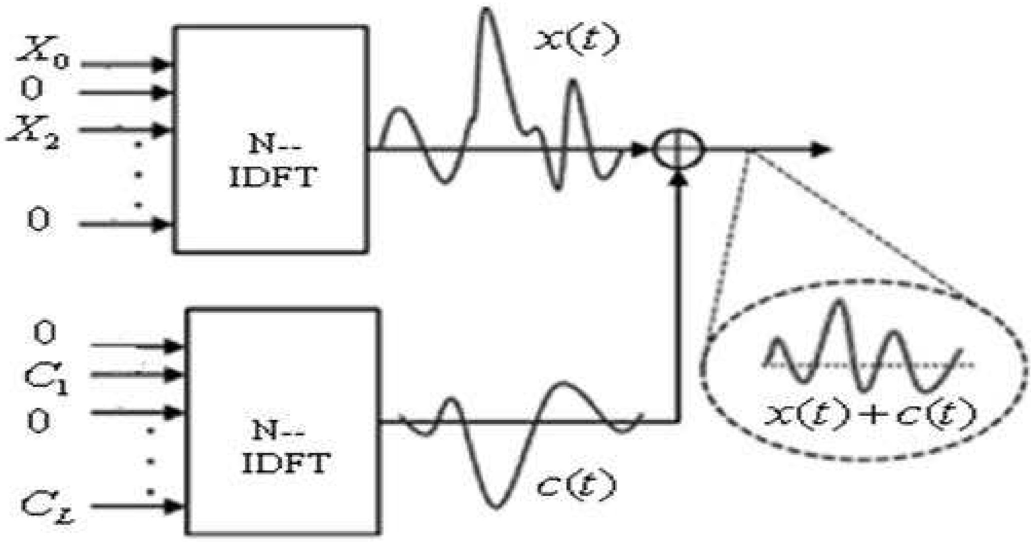

Figure 4 tone reservation

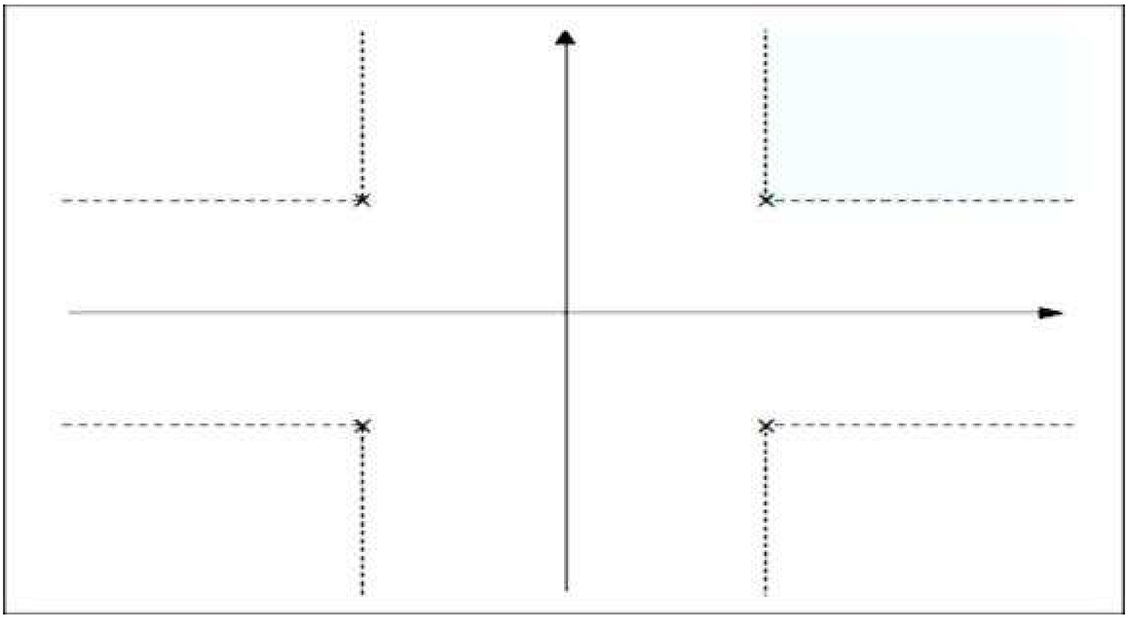

Figure 5 The ACE technique for QPSK modulation

Table 1

Comparative Study of PAPR reduction Techniques

Technique	**Advantage**	**Disadvantage**
Active Constellation Extension(ACE)	No distortion of original signal	Power increase
Partial Transmit Sequence (PTS)	Less complex	Side information needed
Selected Mapping(SLM)	Independent of number of carriers	Side information needed
Tone Injection(TI)	No data rate loss	Requires modulo-D addition after FFT operation in receiver.
Tone Reservation(TI)	No side information needed	Multiple iterations are needed.