An Extensive Survey on Information Data PAPR Reduction Scheme

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Abstract- OFDM is a modulation technique which includes high data rate and strength to interference. These factors are highly essential in todays's high capacity communications systems. OFDM expands the idea of single sub-carrier modulation by utilizing parallel multiple sub-carriers inside a channel. It utilizes lots of separated symmetrical sub-carriers that are transmitted in parallel. PAPR in a wireless communication system is the main limitation of OFDM. PAPR is an estimation of waveform computed from the peak amplitude of the waveform isolated by the RMS estimation of the waveform. This large peak occurs because of the constructive superimposition with various subcarriers or the summation of a huge number of subcarriers. To manage PAPR issue in wireless communication framework, different methodologies are accounted. These strategies incorporate Clipping and Filtering, Tone Reservation, Tone injection, Selected Mapping and Partial Transmit Sequence. A couple of effective approaches utilized for PAPR reduction are reviewed in this examination.

Keywords- PAPR reduction, OFDM, Partial transmit sequence (PTS), selective mapping.

I. INTRODUCTION

The modern digital multicarrier wireless communication system provides high speed data rate at minimum cost for many users as well as with high reliability. In single carrier system, single carrier occupies the entire communication bandwidth but in multicarrier system the available communication bandwidth is divided by many sub-carriers. So that each sub-carrier has smaller bandwidth as compare to the bandwidth of the single carrier system. These tremendous features of multicarrier technique attract us to study Orthogonal Frequency Division Multiplexing (OFDM). OFDM forms basis for all 4G wireless communication systems due to its huge capacity in terms of number of subcarriers, high data rate in excess of 100 Mbps and ubiquitous coverage with high mobility.

OFDM is a multi-carrier modulation (MCM) technique in which complex data symbols are transmitted in parallel after modulating them over orthogonal sub-carrier. In single carrier (SC) system, one complex data is transmitted using one carrier and in this parallel transmission, N complex data are transmitted over N sub-carrier. In the frequency domain, each transmitted sub-carrier results in a sinc function spectrum with side lobes that produce overlapping spectra between sub-carriers. This is presented in Figure. 1.1.

PAPR occurs due to large dynamic range of OFDM symbol waveforms. High PAPR in OFDM essentially arises because of IFFT pre-processing (i.e. OFDM signal consists of a number of independently modulated sub-carriers which can give a large peak when added up with same phases). Here, data symbols across sub-carriers add up to produce high Peak value signals.

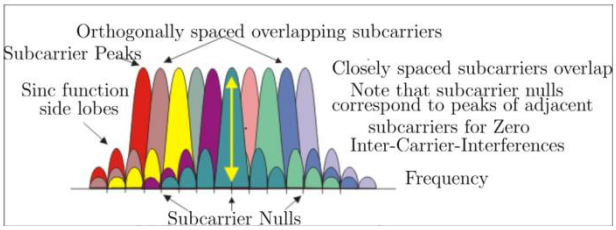

Figure 1.1 OFDM spectrums.

If the deviation of the voltage is small, then signal will still be confined to linear amplification range. But in OFDM system, swing of instantaneous power is very high compared to mean. So, it will cross over into the non-linear range where amplification is non-linear. As amplification is non-linear all the property of OFDM is lost (i.e. orthogonality is lost), then there will be extreme inter carrier interference.

Generally, the radio system uses HPA in the transmitter side to obtain maximum output power efficiency. The operating area of HPA is normally at or near the saturation region. Also the nonlinear characteristics of the HPA are very tender to the difference of the signal amplitudes. This difference in the OFDM amplitudes is very large with high PAPR. So, the high PAPR on the HPA will introduce inter modulation between different sub-carriers and interference into the systems. This interference decreases the BER performance. Also, this high PAPR forces the amplifier for having huge back off power for linear amplification of the signal. This type of linear working amplifier has poor power efficiency.

Digital to Analog Converter (DAC) should have sufficient dynamic range to accommodate the large peaks of the OFDM signals because of the high PAPR. Even if, a high

precision DAC supports high PAPR with low quantization noise, it is very expensive. On the other hand, low precision DAC is cheaper and its quantization noise is more.

PAPR reduction methods can be mainly divided into two domain methods: frequency domain method and time domain method. The basic notion of frequency domain method is to increase the cross correlation of the input signal before IDFT and decrease the output of the IDFT peak value or average value. Selective Mapping (SLM), Partial Transmit Sequence (PTS), Precoding etc. schemes are example of frequency domain method. However, in time domain method, PAPR is reduced by distorting the signal before amplification and adding of extra signals which increase the average power. Clipping and filtering, Peak widowing etc. are examples of time domain method. It is very simple method because it requires very less computational time but introduces the distortion, increases out of band radiation and also degrades BER performance. On comparing between these two domain methods, frequency domain PAPR reduction technique is the most efficient one because of its ability to compress the PAPR without distorting the transmitted signal, no production of in band distortion and out of band radiation in OFDM signals.

II. PAPR REDUCTION SCHEMES

Broadly PAPR reduction techniques are classified into four techniques.

a. Selective Mapping Technique

In SLM technique the input data sequence is multiplied by U number of phases independently. The block diagram for selective mapping technique is shown in Fig. 2.1. The input data block is multiplied with different impendent phases. Signal Scrambling technique scramble each OFDM symbol with different scrambling techniques and select the sequence that gives the smallest PAPR value. It includes methods like Selective Mapping (SLM) and Partial Transmit Sequence (PTS).

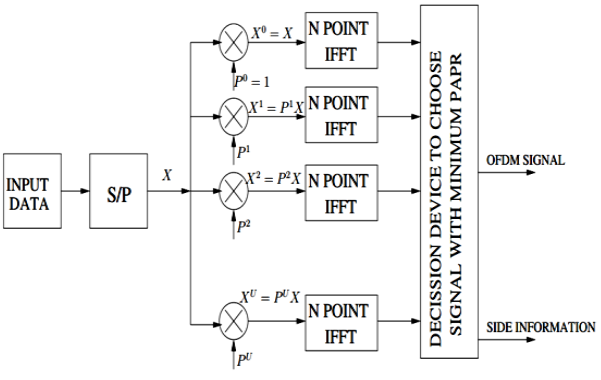

Figure 2.1 Selective Mapping Technique for PAPR Reduction.

b. Signal Distortion Technique

This technique reduces the PAPR by distorting the OFDM signal non-linearly. The methods like clipping and filtering, peak windowing, and non-linear commanding are the example of this technique. These methods are applied after the generation of OFDM signal (after the IFFT).

c. Coding Technique

The coding technique employes some error correcting codes for the PAPR reduction. These methods are applied before the generation of OFDM signal (before IFFT). When N signals are added with the same phase, they produce a peak power, which is N times the average power. The basic idea of all coding schemes for the reduction of PAPR is to reduce the occurrence probability of the same phase of many signals. The coding methods select such code words that minimize or reduce the PAPR.

d. Pre-distortion Technique

The pre-distortion technique is based on the reorientation or spreading the energy of data symbol before taking IFFT. The pre-distortion scheme includes DFT spreading, pulse shaping or pre-coding and constellation shaping.

Partial Transmit Sequence (PTS)

Algorithm was first proposed by Muller S H, Huber J B, which is a technique for improving the statistics of a multi-carrier signal. The basic idea of partial transmit sequences algorithm is to divide the original OFDM sequence into several sub-sequences, and for each sub-sequence, multiplied by different weights until an optimum value is chosen.

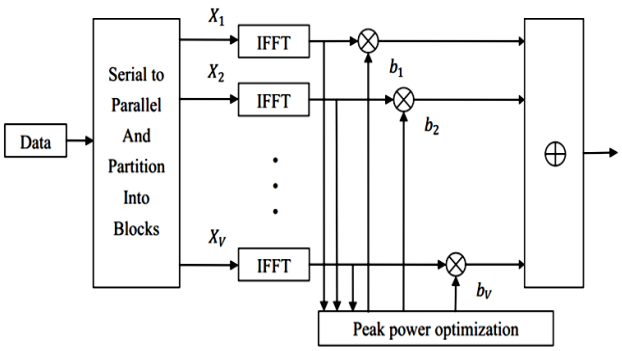

Figure 2.2 Block Diagram of PTS Algorithm.

Fig. 2.2 is the block diagram of PTS algorithm. From the left side of diagram, we see that the data information in frequency domain X is separated into V non-overlapping sub-blocks and each sub-block vectors has the same size N. Hence, we know that for every sub-block, it contains N/V nonzero elements and set the rest part to zero. Assume that these sub-blocks have the same size and no gap between each other, the sub-block vector is given by

$$\hat{X} = \sum_{v=1}^{V} b_v X_v \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (1)$$

In conventional PTS approach, it requires the PAPR value to be calculated at each step of the optimization algorithm, which will introduce tremendous trials to achieve the optimum value. Furthermore, in order to enable the receiver to identify different phases, phase factor b is required to send to the receiver as sideband information (usually the first sub-block bi, is set to 1). So the redundancy bits account for (V- i) $\log_2$ W, in which V represents the number of sub-block, W indicates possible variations of the phase. This causes a huge burden for OFDM system, so studying on how to reduce the computational complexity of PTS has drawn more attentions, nowadays.

Modified PTS Scheme

Based on the discussion above, we had realized that the PAPR reduction performance and computational complexity of PTS algorithm is closely related to the sub-block partition and the value range of weighting factor. Thus, in practical, an effective compromise between system complexity and system performance should be made by choosing appropriate sub block partition scheme and simpler searching scheme for optimum weighting factor. Meanwhile, in traditional PTS reduction scheme, the optimal weighting factor is calculated by thoroughly searched phase factors in a finite set which will increase the complexity of real application.

III. LITERATURE SURVEY

SR. NO.	TITLE	AUTHOR	YEAR	APPROACH
1	A combined PTS-companding scheme for PAPR reduction in OFDM system	X. He, H. Yan, J. He, M. Cai and Z. Jing	2017	A PAPR reduction scheme for OFDM system which combines the partial transmit sequence (PTS) and the companding transformation is reported.
2	A lightweight PAPR reduction scheme using Greatest Common Divisor matrix based SLM technique	M. M. Rahman, M. N. A. S. Bhuiyan, M. S. Rahim and S. Ahmed	2016	In this work explored side information free transmission with GCD default index that achieves higher throughput but sacrifices slight PAPR reduction is reported
3	PAPR reduction scheme: wavelet packet-based PTS with embedded side information data scheme	J. Zakaria and M. F. Mohd Salleh	2016	Reported side information (SI) data as a result of the MCM signal optimisation process. The generated SI data are required to be transmitted with the original data over the channel for successful data recovery at the receiver.
4	Optimal PAPR reduction scheme for MIMO SC-FDMA-performance evaluation study	H. Prakash and C. D. Suriyakala	2015	Reported a coding scheme, space-time block code (STBC) to examine the performance of the system.
5	A novel SER and PAPR reduction scheme for Complex Field Network Coding	Pan Li, Jianjun Hao and Yijun Guo	2014	Reported a novel CFNC scheme, which comprises of two SER and PAPR reduction algorithms.
6	New SLM-Hadamard PAPR reduction scheme for blind detection of precoding sequence in OFDM systems	M. Sghaier, F. Abdelkefi and M. Siala	2014	Reported a novel robust blind SLM technique that avoids sending any explicit (SI), where the selected signal index (SI) is embedded in the transmitted data
7	On the PAPR reduction technique: WP-PTS scheme with embedding the Side Information data	J. Zakaria and M. F. M. Salleh	2013	Reported single main contributions: The Wavelet Packet-based PTS (WP-PTS) scheme with a unique approach of managing the SI data.

X. He, H. Yan, J. He, M. Cai and Z. Jing [1] One of the main disadvantages of Orthogonal Frequency Division Multiplexing (OFDM) communication system is its high peak-to-average power ratio (PAPR). A PAPR reduction scheme for OFDM system which combines the partial transmit sequence (PTS) and the companding transformation is proposed. It takes advantage of the PTS, which does not cause signal distortion with linear transform, and the companding transformation, which is simple and direct. The simulation results show that the new scheme improves the PAPR performance about 0.5dB and 6dB respectively compared to the PTS and companding transformation, and ensures the bit error rate (BER) and transmission rate at the same time.

M. M. Rahman, M. N. A. S. Bhuiyan, M. S. Rahim and S. Ahmed [2] High Peak to Average Power Ratio (PAPR) is one of the major drawbacks for Orthogonal Frequency Division Multiplexing (OFDM) transmitted signal. Among the PAPR reduction techniques, Selected Mapping (SLM) technique is one of the promising one but results in added computational complexity. In this examination applied Greatest Common Divisor (GCD) sequence based SLM method using our proposed reverse searching technique. The proposed scheme is named lightweight as it is very simple to implement and offers improved performance through significant reduction in PAPR and computational complexity. Additionally, we explored side information free transmission with GCD default index that achieves higher throughput but sacrifices slight PAPR reduction.

J. Zakaria and M. F. Mohd Salleh [3] Partial transmit sequence (PTS) is an effective scheme to reduce high peak-to-average power ratio (PAPR) for multicarrier modulation (MCM) signal transmission systems. This approach produces side information (SI) data as a result of the MCM signal optimisation process. The generated SI data are required to be transmitted with the original data over the channel for successful data recovery at the receiver. An effective method for SI data transmission has not yet been identified and research is still ongoing. Hence, introduce a technique that embeds SI data into the original data frame. In this study, a wavelet packet (WP)-based PTS (WP-PTS) scheme is selected as the MCM transmission method. The proposed scheme is called WP-PTS with embedded SI data. In addition, a suitable scheme for reconstructing the original data is developed. Simulation result shows that the PAPR performance of the proposed scheme improves by up to 2.5 dB at a complementary cumulative distribution function level of 10-4 compared with the original WP-orthogonal frequency-division multiplexing system without the PAPR reduction scheme when the number of selected disjoint subblocks is 16.

H. Prakash and C. D. Suriyakala [4] The standard organization Third Generation Partnership Project (3GPP) aiming high data rate and high throughput developed long term evolution (LTE). Two multiple access schemes used in LTE for satisfying the requirements of high data rate and high throughput are Orthogonal Frequency Division Multiple Access (OFDMA) and Single Carrier Frequency Division Multiple Access (SC-FDMA). But a major problem faced by OFDMA is higher peak to average power ratio (PAPR) that causes an increase in the power of transmitter in uplink. Therefore for uplink transmission, OFDMA scheme cannot be considered. In uplink, a modified form of OFDMA called SC-FDMA can be used where the subsequent transmission of subcarriers helps to reduce the PAPR of the signal. Through the use of space-frequency block code (SFBC), the low PAPR property of SC-FDMA system gets damaged whereas modified SFBC reduces PAPR but causes only slight bit error rate (BER) deterioration. In this examination present another coding scheme, space-time block code (STBC) to examine the performance of the system. Results obtained for the work shows that the use of our proposed scheme helps to attain a good reduction in PAPR along with acceptable BER degradation.

Pan Li, Jianjun Hao and Yijun Guo [5] For multi-source relay-based cooperative communications, it is widely believed that Complex Field Network Coding (CFNC) achieves better throughput performance than Physical-layer Network Coding (PNC). However, traditional CFNC schemes suffer a considerable loss on the performance of symbol to error ratio (SER) and peak-toaverage power ratio (PAPR) as the number of source nodes increases. In this work, to tackle this problem in some extent, a novel CFNC scheme, which comprises of two SER and PAPR reduction algorithms, is proposed and analyzed. Particularly, by optimizing the complex coefficient vector at the source nodes at first, the performance of SER is improved; while by shrinking the amplitude of some signals selectively, the PAPR at the destination nodes is reduced. Simulations are provided to validate our analytical results. From the simulation results, it is observed that the proposed CFNC scheme significantly improves the performance of SER and PAPR.

M. Sghaier, F. Abdelkefi and M. Siala [6] Selected Mapping (SLM) is a promising technique dedicated to reduce the Peak-to-Average Power Ratio (PAPR) in OFDM systems. In this technique, different representations of OFDM symbols are generated by rotating the original frame using different phase sequences. Then, the signal having the minimum PAPR is selected and transmitted. To compensate the effect of the phase rotation at the receiver side, it is necessary to transmit the index of the selected

phase sequence as an explicit Side Information (SI). In this exploration work propose a novel robust blind SLM technique that avoids sending any explicit (SI), where the selected signal index (SI) is embedded in the transmitted data by using an adequate transformation such as the Hadamard one. Furthermore, in order to recover the used (SI) index, we propose an optimized scheme which exploits mainly the higher-order statistics moments and cumulants of the received signal. We show that our proposed method guarantees a reliable signal recovery at the receiver side and dramatically reduces the PAPR level at the transmitter side. Simulation results are given to support our claims.

J. Zakaria and M. F. M. Salleh [7] The Partial Transmit Sequence (PTS) scheme is magnificent in reducing the high peak-to-average power ratio (PAPR) in multicarrier modulation (MCM) signals. However, the scheme produces Side Information (SI) data as the result of optimization which reduces the high PAPR of the signals. The SI data must be transmitted along with the optimized information data over the channel. Due to this, we develop a design of embedding the SI data into the Wavelet Packet-based OFDM (WP-OFDM) frame and able to reconstruct the original information by utilizing a simple reconstruction technique at the receiver. This work presents single main contributions: The Wavelet Packet-based PTS (WP-PTS) scheme with a unique approach of managing the SI data. The WP-PTS scheme is the combination of WP-OFDM system and conventional PTS scheme. In fact, WP-PTS scheme has similar structure as conventional PTS scheme except different signal transformation block is utilized. The PAPR performance of embedding SI data using WP-PTS scheme is compared with WP-PTS scheme under similar conditions. A PAPR profile of uncoded WP-OFDM signal is also included. Results show that the PAPR profile of WP-PTS scheme with embedding SI data has converged towards PAPR profile of WP-PTS scheme. The WP-PTS scheme with embedding SI data obtained 3.0dB improvement if compared to uncoded signal at 10-4 of CCDF level with small lost in BER performance.

IV. PROBLEM IDENTIFICATION

In OFDM system, the output is the superposition of multiple sub-carriers. In this case, some instantaneous power outputs might increase greatly and become far higher than the mean power of the system when the phases of these carriers are same. This is also defined as large Peak-to-Average Power Ratio (PAPR). High PAPR is one of the most serious problems in OFDM system. To transmit signals with high PAPR, it requires power amplifiers with very high power scope. These kinds of amplifiers are very expensive and have low efficiency-cost. If the peak power is too high, it could be out of the scope of the linear power amplifier. This gives rise to non-linear distortion which changes the superposition of the signal spectrum resulting in performance degradation. If there are no measures to reduce the high PAPR, OFDM system could face serious restriction for practical applications.

V. CONCLUSION

This work presents an extensive survey of literature on a PAPR reduction scheme based on wavelet packet-based PTS. Based on broad perusing and concentrate of related investigation and writing in this investigation field. Among distinctive recommendations, concentration is primarily on the signal scrambling technology. Examine the strategy for choosing appropriate mapping and partial transmit sequence. A progression of itemized examination comes about were acquired of these two plans from the edge of PAPR reduction execution, excess of assistant data and additionally intricacy of framework. OFDM as a multi-carrier modulation technique particularly suited for high-speed wireless transmission. This examination is mainly focused on the evaluating of various PAPR reduction performances in OFDM system. However, there are still many challenges to design an efficient wireless communication system.

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