A Study of Various PAPR Reduction Techniques in OFDM System

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Abstract: ***Orthogonal Frequency Division Multiplexing (OFDM) is an orthogonal multicarrier communication system. High data rate, Bandwidth efficiency, and immune to fading makes the OFDM systems preferred choice for modern communication system. However, it faces Peak-to-Average Power Ratio (PAPR) problem that is a major drawback of multicarrier transmission system which degrades the performance of power amplifier. To overcome this problem there are many methods PTS is one of those. In this paper review of various PAPR reduction methods is done and proposes a Interleaved partitioned PTS with DCT technique. Proposed method can have lesser computational complexity and better PAPR reduction capability.***

Keywords: Orthogonal Frequency Division Multiplexing (OFDM), Peak to Average Power Ratio(PAPR), Partial Transmitt sequence(PTS), Discrete cosine transform(DCT).

1. Introduction

Orthogonal frequency division multiplexing (OFDM) technology is one of the foremost engaging candidates for fourth generation wireless communication. It effectively combats the multipath fading channel and improves bandwidth efficiency. At the same time, OFDM also will increase system capacity so on give a reliable transmission. It uses the principle of Frequency Division Multiplexing (FDM) but in far more controlled manner, permitting an improved spectral efficiency.

The basic principle of OFDM is to divide a high-rate data stream into variety of lower-rate streams that are transmitted at the same time over variety of subcarriers. These subcarriers are overlapped with each other. as a result of the symbol duration increases for lower rate parallel subcarriers, the relative amount of dispersion in time caused by multipath delay spread is reduced. Inter-symbol interference is eliminated nearly fully by introducing a guard time in each OFDM symbol. The key challenges are isi due to multipath-use guard interval, large peak to average ratio due to non linearities of amplifier; phase noise issues of oscillator, need frequency offset correction in the receiver. large peak-to-average power ratio that distorts the signal if the transmitter contains nonlinear parts like power amplifiers (PAs). The nonlinear effect on the transmitted OFDM symbols are spectral spreading, inter modulation and dynamic the signal constellation. In other words, the nonlinear distortion causes each in-band and out-of-band interference to signals. therefore the PAs needs a back off which is around up to the PAPR for distortion-less transmission. This reduces the efficiency for amplifiers. Therefore, reducing the PAPR is of practical interest. several PAPR reduction strategies are proposed. Some strategies are designed supported using redundancy, like coding, selective mapping with explicit or implicit side information or tone reservation. an apparent result of using redundancy for PAPR reduction is the reduced transmission rate. PAPR reduction might also be achieved by using extended signal constellation, like tone injection, or multi-amplitude CPM. The associated disadvantage is that the increased power and implementation complexity. a simple PAPR reduction technique can be achieved by clipping the time-domain OFDM signal.

PAPR is defined as the ratio of the maximum peak power and average power for the same OFDM signal:

$$PAPR(dB) = 10\log_{10}\frac{\max\{|Xn|^2\}}{\mathrm{Av}\{|Xn|^2\}} \quad (1)$$

The organisation of the paper is as follows literature survey is given in section 2, section 3 gives conclusion of literature review. Section 4 gives an idea about problem associated with OFDM. Section 5 different strategies associated with PAPR reduction technique is discussed in this section. Section 6 concludes the paper.

2. Literature Review

Many works have been done in the past in the field of PAPR reduction of OFDM system and various methods were adopted for reductionChen Hong et.al [1]proposes a new random interleaved segmentation methodology, which combines random segmentation and interleaved segmentation, some blocks use random segmentation, whereas the others use interleaved segmentation. proposed methodology can reduce the normal PTS algorithm computational complexness, so as to higher improve the performance of system.

Prasanta Kumar Pradhan et.al [2] proposed a technique of reducing the peak to average power ratio in OFDM system, based on DCT aided successive addition and subtraction of OFDM symbols within the single OFDM frame. Performance of the proposed technique is evaluated and found to be superior to PTS & SLM techniques.

Jaturong Sarawong et.al [3] proposes a new phase factors for Partial Transmit Sequence (PTS) technique with interleaved partitioning scheme, which can improve the PAPR performance as compared with the traditional PTS technique, without any increasing of side information and the computational complexness.

Zihan Wang et.al [4] propose an undistorted PAPR reduction technique for OFDM systems, which combines the Interleaving methodology and a modified Partial Transmit Sequence (PTS) technique with the new phase rotation. The computational complexness of Interleaving methodology is lower, compared with PTS. However, the PAPR reduction performance of Interleaving methodology is worse than the PTS technique.

E.Kalaiselvan et.al [5] uses Pseudo-random PTS that uses cyclic shifting of subblock sequences is proposed to eliminate the requirement of side info. Simulation shows that the proposed scheme performs very well in terms of PAPR. The proposed scheme achieves nearly constant bit error rate (BER) performance as the C-PTS with excellent side info, under frequency selective fading condition.

V.Vinayaka et.al [6] fountain codes are used to control Peak-to Average Power ratio of OFDM signals. By using this code OFDM packets may be generated with a low PAPR. in this paper, effective PAPR reduction technique like as Partial Transmit Sequence (PTS) and Selective Mapping (SLM) are used beside fountain codes. Among them PTS with fountain codes shows higher PAPR reduction than SLM with fountain codes.

Abolfazl Ghassemi et al [7] Partial transmit sequence (PTS) is a verified technique to reduce the peak-to-average power ratio (PAPR) in orthogonal frequency division multiplexing (OFDM) systems. It achieves significant PAPR reduction without distortion, however the high computational complexness of multiple Fourier transforms is a drawback in practical systems. to address the complexness, signals at the middle stages of an N-point radix FFT using decimation in frequency (DIF) are utilized for PTS subblocking. they formulate OFDM symbols based on these signals to use the periodic autocorrelation function (ACF) of the vectors within the PTS subblock partitioning. Error-correcting codes (ECCs) are utilized within the subblocking for the PTS radix FFT. This new technique considerably decreases the computational complexness while providing comparable PAPR reduction to ordinary PTS (O-PTS), even with alittle number of stages after PTS partitioning. Numerical results are presented which make sure the PAPR improvements.

Sulaiman A et al [8] the main objective of this project is to reduce Peak to Average Power ratio (PAPR) in wireless communication systems. PAPR plays a major role in communication systems for determining the transmitted signals efficiency at the receiver side. For reducing PAPR; Clipping, up scaling, down scaling , up - down scaling and selected Mapping algorithmic rule techniques are introduced. The amplitude of complex OFDM signal is clipped then scaled in such a way in order that the PAPR is reduced without inflicting much degradation in bit error rate (BER). Total OFDM system is designed with QPSK modulation, frequency domain to time domain conversion (IFFT), corresponding reverse operation at receiver side. Synchronous OFDM with low PAPR and low bit error rate is introduced to attain high data rate and accurate signal transmissions.

Le Goff S et al [10] selected Mapping (SLM) is a PAPR reduction technique, that converts the OFDM signal into many freelance signals by multiplication with the phase sequence set and transmits one among the signals with lowest PAPR. however it needs the index of the chosen signal i.e. side information (SI) to be transmitted with every OFDM symbol. The PAPR reduction capability of the SLM technique depends on the choice of phase sequence set. in this paper, they proposed a new phase sequence set generation technique based on M-ary chaotic sequence and a mapping scheme to map quaternary information to concentric circle constellation (CCC) is employed. it is shown that this methodology doesn't need SI and provides higher SER performance with good PAPR reduction capability as compared to existing SLM OFDM strategies.

T. Jiang et al [11] Orthogonal frequency division multiplexing (OFDM) has been adopted as a standard for several modern wireless applications requiring high data rate due to bandwidth efficiency, resistance to frequency selective fading and easy digital realization using IFFT/FFT operations. However, physical implementation of the OFDM system suffers from many difficulties. one among the most important limitations of OFDM is that it suffers from high peak-to-average power ratio (PAPR), which results in inter-carrier interference (ICI), high out-of-band radiation, and degradation of bit error rate performance. in this paper, different OFDM PAPR reduction techniques are reviewed and analyzed supported their computational complexness, bandwidth demand and error performance.

C. Pradabpet et.al [13] they propose a new Power ratio (PAPR) reduction technique employing a partial transmit sequence (PTS) combined with adaptive peak power reduction (APPR) strategies. this method is employed in a system based on Orthogonal Frequency Division Multiplexing (OFDM). so as to reduce PAPR, the sequence of input information is rearranged by the PTS for the reduction of PAPR and then fed to the APPR method in the proposed system. The APPR methodology controls the peak level of the modulation signal by an adaptive algorithmic rule. The proposed methodology shows the improvement on PAPR, on the power spectrum density (PSD) and on the high performance on bit error rate (BER) of an OFDM system.

3. Conclusion of literature review

Orthogonal Frequency Division Multiplexing (OFDM) is taken into account to be a promising technique against the multipath fading channel for wireless communications. However, OFDM faces the Peak-to-Average Power ratio (PAPR) drawback that is a major drawback of multicarrier transmission system which results in power inefficiency of system. several strategies have been proposed to reduce the high PAPR problem.The` PAPR can be reduced by frequency domain techniques like block coding, interleaving, selected Mapping (SLM), and Partial Transmit Sequences(PTS) via performing some operations on the transmitted OFDM signals. SLM and PTS are very versatile schemes and have a good performance of the PAPR reduction without any degradation. However, these two strategies need high system complexness and heavy computational burden, due to the numerous IFFT stages and

complex optimization procedure. In PTS technique complexness are often reduced using segmentation.

4. Problem Definition

Orthogonal Frequency Division Multiplexing (OFDM) faces the Peak-to-Average Power ratio (PAPR) drawback that's a serious drawback of multicarrier transmission system that results in power inefficiency of system.

PAPR is the main problem of the application of this technology that means radio frequency power amplifier of the system must have a wide linear range to avoid transmission signal spectrum spreading and non-linear distortion resulting in higher cost and higher power, as well as greater difficulty of realization.

The larger PAPR would cause the severe degradation of bit error rate (BER) performance due to the intermodulation noise occurring in the non-linear amplifier.

5. Methodologies

5.1 Partial Transmit Sequence

In CPTS, the input symbol sequence in the frequency domain is firstly partitioned into several subblock sequences by employing the corresponding subblock partition methods, where only a part of subcarrier signals exist and the other ones are padded by zeros. Let X and V be the input symbol sequence and the number of subblock sequences respectively.

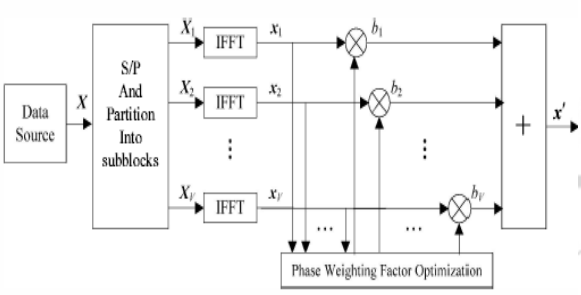

Figure 1: Block diagram of Partial Transmit Sequence

After the subblock partition is completed, the input sequence can be expressed by

$$X = \sum_{i=1}^{v} Xi \tag{2}$$

where X; denotes the ith subblock sequence.

For each subblock, a phase weighting factor is adopted for weighting it. Then, by employing TFFT operation, the candidate sequence x' can be obtained, given by

$$x' = IFFT\{\sum_{i=1}^{V} biXi\} = \sum_{i=1}^{V} bi \cdot IFFT\{Xi\} = \sum_{i=1}^{V} bixi \tag{3}$$

where b; denotes the phase weighting factor for ith subblock sequence and X; represents the ith subblock sequence in the time domain.

Finally, among all the candidate sequences, the one with the lowest PAPR is chosen for transmitted. The block diagram of CPTS scheme is shown in Figure 1.

At the receiver, in order to recover the original data sequence successfully, the side information must be required. Assume there are Wallowed phase weighting factors in CPTS. Thereupon, we can obtain WV-1 candidate sequences, whereV denotes the number of subblock sequences. Thus, 11og,WV -ll bits are needed to represent this side information,where !·l denotes the element to the nearest integers towardinfmity.

5.2 DCT (Discrete Cosine Transform)

DCT has widely used for the data compression. The signal decomposition supported by DCT algorithms has four important steps: dividing a signal into N sub-parts; DCT computation for each block; Thresholding & quantisation of the DCT coefficients; and coding of the quantized DCT coefficients discrete cosine transform is given by

$$X(n) = \left(\frac{1}{N}\right)^{\frac{1}{2}} \sum_{i=0}^{N-1} x(i) \cos\left[\frac{\pi n}{2N}(2i+1)\right] \tag{4}$$

While the inverse IDCT is given as:

$$x(i) = \left(\frac{1}{N}\right)^{\frac{1}{2}} \sum_{n=0}^{N-1} X(n) \cos\left[\frac{\pi i}{N}(2n+1)\right] \tag{5}$$

DCT provides the decomposed coefficient of the initial signal and it provides a lot of weight to low-pass coefficients to high-pass coefficients.

5.3 Selected Mapping

The key idea in chosen Mapping is that the formation of many sequences that carry identical data [7, 8]. this is often achieved by multiplying the information block with number section sequences generated. The PAPR value of every sequence is calculated. and also the sequence with minimum peak-to- average power magnitude relation is chosen for transmission.

5.4 Coding Schemes

If N signals are added in same section, they turn out high peak power that is N times the average power. The key plan behind coding scheme is to cut back the occurrence probability of same section signals. the most disadvantage of coding scheme is that the great performance of the PAPR reduction is achieved at the price of coding rate loses.

5.5 Nonlinear Companding Transforms

Nonlinear Companding Transforms enlarge the small signals and compress the large signals to increase the immunity of small signals from the noise [9]. The fIrst nonlinear companding transform is the fJ-law companding. This transform is based on the speech processing algorithm fJ- law, and it gives better performance than the clipping method. fJ -law mainly focuses on enlarging signals with small amplitude and keeping peak signals unchanged. NCT may lead to significant distortion and performance loss due to companding noise.

5.6 Tone Rejection and Tone injection

The key idea behind Tone Rejection and Tone Injection is that both the transmitter and the receiver reserve a subset of tones for generating PAPR reduction signal. In Tone Reservation the main concern is to fInd time domain signal C to add with the original time domain signal x to reduce the PAPR. The basic idea of Tone Injection is to extend the constellation and thus to form the same data points corresponding to multiple possible constellation points.

6. Conclusion

High peak-to-average power ratio is a challenging issue in Orthogonal Frequency Division Multiplexing. From the study of various PAPR reduction techniques it is observed that PTS is one the best technique but the computational complexity is more[6]. PAPR value is found in various papers based on PTS are in the range of 8dB- 11dB. To increase the PAPR reduction capability and low complexity Interleaved partitioned PTS with DCT technique is proposed for further work.

References

[1] Chen Hong, Qin Qin & Tang Chao, "An PTS Optimization Algorithm for PAPR Reduction of OFDM System," IEEE Transactions on Mechatronic Sciences, Electric Engineering and Computer (MEC), pp. 3775-3778, December 2013

[2] Prasanta Kumar Pradhan, Satyendra Singh Yadav & Sarat Kumar Patra, "PAPR Reduction in OFDM systems," Annual IEEE India Conference (INDICON), 2014

[3] Jaturong Sarawong, Tanairat Mata, Pisit Boonsrimuang and Rideo KobayashI, "Interleaved Partitioning PTS with New Phase Factors for PAPR Reduction in OFDM Systems," IEEE Conference on Mechatronic Electrical Engineering Electronics, Computer, Telecommunications and Information Technology (ECTI) Association of Thailand, pp. 361-364, 2011.

[4] Zihan Wang, Jiang Zhu and Kai Gao, "Proposal of PAPR reduction method for OFDM signal by optimized PTS combined with INTERLEAVING method," IEEE Conference on ChinaSIP, pp. 943-947, 2015.

[5] E.Kalaiselvan, P.Elavarasan and G.Nagarajan, "PAPR Reduction of OFDM Signals using Pseudo Random PTS without Side Information," IEEE International conference on Communication and Signal Processing, pp. 29-33, April 3-5, 2013

[6] V.Vinayaka, P.Elavarasan and G.Nagarajan, "Reduction of PAPR in OFDM signals using Fountain coded PTS," IEEE International conference on Communication and Signal Processing, pp. 120-124, April 2013.

[7] Abolfazl Ghassemi and T. Aaron Gulliver, "PAPR Reduction of OFDM Using PTS and Error Correcting Code Subblocking," IEEE Transactions on wireless communications, vol. 9, no. 3, pp. 980-989, March 2010.

[8] Sulaiman A. A., Ehab F. B., Mohamed Darwish A. E., "Linear Companding Transform for the Reduction of Peak-to-Average Power Ratio of OFDM Signals", IEEE Transaction Broadcasting, Vol. 55, No. 1, pp. 195-200, March 2009.

[9] Jiang T., Wu Y., "An Overview: Peak-to-average power ratio reduction techniques for OFDM signals", IEEE Trans. Broadcasting, vol. 54, No. 2, pp. 257–268, Jun. 2008.

[10] Le Goff S. Y.,.Al-Samahi S.S, Boon K. K., Tsimenidis C. C., Sharif B. S., "Selected Mapping without Side Information for PAPR reduction in OFDM", IEEE Transaction on Wireless Communications, Vol. 8, No. 7, pp. 3320–3325, July 2009.

[11] Seung Hee Han and Jae Hong Lee, "An Overview of Peak to Average Power ratio reduction techniques for Multicarrier transmission," IEEE Wireless Communication, vol. 12, no. 2, pp. 56–65, April 2005.

[12] Breiling M., Muller-Weinfurtner S., Huber J., "SLM peak power reduction without explicit side information", IEEE Communication Letters, Vol. 5, No. 6, pp. 239–241, Jun. 2001.

[13] C. Pradabpet, K. Dejhan "A new PAPR reduction in OFDM systems using PTS combined with APPR for TWTA nonlinear HPA" Songklanakarin J. Sci. Technol. 30 (3), 355-360, May - Jun. 2008.

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