A Low-Complexity Clipping based SLM-PTS for PAPR Reduction in the OFDM system

Lokesh C[1], Dr. Rekha K R[2], Dr. Nataraj K R[3]
[1]*Vidyavardhaka Collehe of Engineering(VVCE), Mysuru.*
[2,3]*SJBIT, Bengaluru*
(E-mail: Lokesh.c@vvce.ac.in)

Abstract—This electronic document is a "live" template and already defines the components of your paper [title, text, heads, etc.] in its style sheet. *CRITICAL: Do Not Use Symbols, Special Characters, or Math in Paper Title or Abstract. (Abstract) Orthogonal Frequency Division Multiplexing (OFDM) is one of the significant systems for Fourth Generation (4-G) wireless communication. The OFDM communication system faces the Peak-to-Average Power Ratio (PAPR) problem, which is the major limitation of the multicarrier transmission OFDM system. Clipping based Selective Mapping (SLM) and Partial Transmit Sequence (Clipping-SLM-PTS) technique is introduced to reduce the PAPR in OFDM system. The clipping based PTS and SLM techniques have derived effective PRPR reduction compared to conventional techniques. The Clipping-SLM-PTS technique is used for minimizing the complexity ratio and achieving PAPR reduction in the OFDM system. The simulations result showed that clipping-SLM-PTS technique has reduced 1-1.17 % of PAPR compared to existing methods such as SLM, PTS and SLM-PTS.

Keywords—*Clipping, Orthogonal Frequency Division Multiplexing, Peak-to-Average Power Ratio, Partial Transmit Sequence, Selecting Mapping*

I. INTRODUCTION

The OFDM is an attractive system in wireless communication [1]. The OFDM based systems are mostly employed for wireless applications such as European DAB, DVB Wireless Land Area Networks (LANs) and Broadband Fixed Wireless Systems (BFWS) because it provides high-spectral efficiency, immunity to the impulse noise, multipath delay spread tolerance and robustness against frequency selective fading channels [2] [3]. The OFDM is a multicarrier modulation method use the orthogonality of the subcarriers. The OFDM system is applicable for high data rate application based on its flexible management of Inter-Symbol Interference (ISI) in high dispersive channels [4]. The OFDM system provides strength not in favor of ISI and multipath fading due to a low-rate subcarrier and increases symbol period, which is robust against narrowband interference. The OFDM system allows Radio Frequency (RF) with the utilization of an adaptive modulation scheme. It enables the bandwidth on demand technology and privileged spectral efficiency. Hence, the OFDM doesn't require adjacent bandwidth for Inverse Fast Fourier Transform (IFFT) operation. The OFDM system creates its own frequency network, which is suitable for broadcasting applications [5]. In the present days, the OFDM system faces the PAPR problem in multicarrier transmission OFDM.

Increase of PAPR in the OFDM system leads to different distortions, like inter symbol interference in the transmitter chain, amplitude frequency, degradation of the system performance (Bit Error Rate (BER)), high linear power amplifiers that maximize the cost of the system [6]. In recent years, several techniques on PAPR reduction were introduced in the OFDM system, those techniques are Linear Block Coding (LBC) [7], [8], Peak Insertion (PI), Interleaving technique [9], [10], tone reservation [11], [12], SLM [13] [14], and PTS technique [15] and so on. The conventional PAPR reduction techniques have some drawbacks such as less PAPR reduction in maximum transmit power, reduced data rate, boosted BER and increased computation complex. So, to overcome this problem, this paper presented Clipping based SLM-PTS technique that involves in the reduction of the PAPR based on the basis of complexity and generates automatic side information. The PAPR reduction and accuracy of the system are high in Clipping based SLM-PTS technique.

This research work is composed as follows, section 2 presents a brief survey of recent papers on PAPR reduction techniques. In the section 3, briefly explained the proposed clipping based SLM-PTS technique for PAPR reduction. The section 4 described comparative experimental results of a proposed clipping based SLM-PTS technique compared to the existing method. Conclusion of this research work made in section-5.

II. LITERATURE SURVEY

The researchers have suggested several techniques for PAPR reduction in the OFDM system. This section presented a brief evaluation of some significant contributions on the OFDM research.

Hu et al. [16] proposed chaos based PTS (CTPS) method for physical layer security in the OFDM Passive Optical Network (PON). A four-dimensional hyper chaos was used to generate the chaotic partition data and chaotic phase weighting factors in the PTS as well as chaotic training sequence for symbol synchronization. This provided a large key space to improve the physical layer. The proposed method improved the performance of the OFDM transmission due to the high reduction of the PAPR in the OFDM system using the chaotic random PTS technique. The proposed method provided better PAPR reduction, but that increases computation complexity.

Kinjal P. Anand [17] presented the PTS technique reduced the PAPR value in the OFDM system. In this paper, input data symbols were classified into disjoined sub-blocks and the sub-blocks were separately phase rotated by an individually selected phase factors along with the process of enhancing the performance of PAPR in OFDM system. The complexity of the proposed PTS technique could be reduced by the application of a modern phase sequence. The PTS technique was able to attain significant performance. But, this technique increases the searching complexity exponentially with the number of sub-block which is the major drawback.

Amrutha et al. [18] proposed PTS technique called as serial PTS and parallel PTS to reduce the computational complexity of the PTS method based on weighting factors chosen from the code-wards of the linear block codes. In this paper, phases were randomly generated and the generated phases were multiplied. Hence, the data has been modified by employing the phase manipulations when the PAPR was reduced in OFDM. The parallel and serial PTS technique had reduced computational complexity and provided error correction capability for weighting factors. The PTS algorithm has achieved a low PAPR and less redundancy. But, the proposed technique was not compared with any existing methods.

Ku et al. [19] proposed a new PTS technique named as Space Frequency Coding (SFBC) in the Multiple Input and Multiple Output (MIMO) OFDM systems for reducing PAPR. The PTS technique has used the sample list of powers in the sub-blocks in order to generate cost function for the selection of samples, which is used to estimate the peak power of each and every candidate signal that resulted in the reduction of the system complexity. The simulation result confirmed that, this particular PTS technique attained less PAPR and BER rate with less computational cost. A lot of computations were required to choose a best candidate sequence using a sub optimal algorithm that leads to complex problems.

Wang et at. [20] presented Selective Weighting - PTS (SW-PTS) technique for reducing PAPR in the OFDM system. In the SW-PTS technique, selective weighting sub-block sequence was firstly used for reducing computational complexity. In this work, to maximize the number of the OFDM candidate sequence, few specific phase weighting sequence was generated for weighting the initial sub-block sequence. The computer simulations showed that proposed SW-PTS have achieved a less computational complexity and PAPR reduction compared to the Original PTS technique. As, this method consists of several iterations, its computation time is more.

Clipping based SLA-PTS technique is implemented for reducing PAPR in the OFDM system. The principle of the proposed clipping based SLM-PTS technique is briefly explained in the below section.

III. CLIPPING BASED SLM-PTS TECHNOLOGY

Figure 1 shows the block diagram of the Clipping-SLM-PTS technique. Clipping technique is well known non-linear PAPR reduction technique, which has non-linear bandwidth, less computational complexity and easy in implementation without receiver-side cooperation. While the SLM and PTS technique are known to provide better performance in PAPR reduction without any kind of signal distortion.

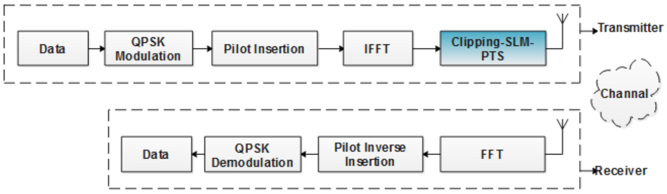

Fig. 1 Block diagram of the Clipping-SLM-PTS technology

Block diagram of the Clipping-SLM-PTS technique consists of the five major blocks in the transmitter side, those are, data block, a modulation block, pilot insertion block, IFFT block and Clipping-SLM-PTS block. The receiver side consists of four major sub blocks, those are FFT, pilot inverse insertion and QPSK. This research work used QPSK modulation and their higher orders over the Additive White Gaussian Noise (AWGN) channel. In the OFDM system, initially a fixed number of the input data samples are modulated and then jointly correlated together by employing IFFT at the transmitter side. Mathematically, an IFFT associates all the input signals to produce each and every signal of the output OFDM symbol. Mathematically, equation (1) presents the input frequency domain sequences.

$$P = [P_0, P_1, \ldots P_{N-1}] \quad (1)$$

Here, N represents the dimension of the input data and P denotes the input data. In the initial stage, the regulated input frequency samples of OFDM modulate into time domain sequences, because the OFDM system encodes only digital data on multicarrier frequency. The following subcarrier sequence select orthogonality to provide multiple transmissions. Equation (2) presents modulated time domain signals.

$$p_n = \frac{1}{\sqrt{2}} \sum_{k=0}^{n-1} P_n W_N^{kn} \quad (2)$$

Here, P_n represents the signal further processed by IFFT, kn represents the orthogonal value of the subcarriers. The shifting sequence of the data is added with data signal to reduce the PAPR in the OFDM sequence of the signal. The summation of the OFDM symbols in the sub-carriers is compared with the individual carrier system and that synthesis may lead to high PAPR. This high-power is denoted as the ratio between maximum power and average power that is expressed in the equation (3).

$$PAPR = 10 \log_{10} \frac{\max\left\{|p_n|^2\right\}}{E\left\{|s_n|^2\right\}} \quad (3)$$

Here, $E\left\{|s_n|^2\right\}$ represented as the average power of p_n, it can be calculated as a frequency domain of IFFT unitary transformation type. This IFFT output is given to the input of the clipping algorithm, which is described in the next section.

A. Clipping based SLM-PTS technology

The selection of clipping level is significant problem in clipping technique. However, an improper level can diminish the PAPR. To diminish PAPR in the OFDM system, a clipping operation is applied in the OFDM signal and this operation is denoted in the equation (4).

$$C\left[p_i(n)\right] = \begin{cases} p_i(n) \ if \ |p_i(n)| \le CL \\ CLe^{j\phi} \ if \ |p_i(n)| > CL \end{cases} \quad (4)$$

Here, $p_i(n)$ is discrete time OFDM symbol, i=1,2,3,….represents the transmit antenna and $\phi = \Delta p_i(n)$ represents the phase angle of the $p_i(n)$ The CL value depends on the clipping ratio (CR) represented in the equation (5).

$$CR = 20\log 10\left({CL}/{E\left[p_i(n)\right]} \right) \quad (5)$$

The clipping is the simplest PAPR reduction technique of the OFDM system. But, this technique introduces out-of band and in-band distortions, which reduces the BER performance. However, the out-band distortion can be eliminated by filtering the clipping signal and in-band distortion can be reduced by oversampling. In this work, the clipping technique reduces the number of the samples and an electrical average power by half. The output of Clipping technique is given to the input of the SLM-PTS block for reducing the PAPR reduction. A number of IFFT blocks can be replaced by perfect sequence obtained from base vectors. Here SLM selects the block of the original signal with different phase sequence in the frequency domain and that has low PAPR value. The Clipping-SLM-PTS technique input sequence P is divided into two-disjoint sub-block and then over sampled every block by a factor of A by placing ${N}/{2}$ zeros in the middle of every sub-block which is represented in equation (6) and (7).

$$p_1 = \left[P_0, P_1, ...P_{\frac{N}{4}-1}, \frac{0,0,0,}{\frac{(A-1)N}{2}}, p_{\frac{N}{4}}{}' P_{\frac{3N}{4}}{}' P_{\frac{N}{2}-1} \right]^T \quad (6)$$

$$p_2 = \left[P_{\frac{N}{2}}, P_{\frac{N}{2}+1}, ...P_{2\frac{N}{4}-1}, \frac{0,0,0,}{\frac{(A-1)N}{2}}, p_{\frac{N}{4}}{}' P_{\frac{3N}{4}}{}' P_{n-1} \right]^T \quad (7)$$

Here, A represents the sampling factor and N denotes the number of the subcarriers. After performing the IFFT operation of these sub-blocks TD signals: p_1 and p_2 can be generated circularly convolved with the vectors H_1, H_2^0 that gives the signals: s_{11}, s_{12}^0 and s_{21}, s_{22}^0. Then the sub-block candidate signals p_1^v, p_2^v will be generated by using equation (8) and (9).

$$p_1^v = s_{11} + s_{12}^v \quad (8)$$

$$p_2^v = s_{21} + s_{22}^v \quad (9)$$

Next, candidate signals of an OFDM signal are generated by combining initial sub-block signals to the second sub-block signals that are $\left(p_1^1 \ to \ p_2^1, p_1^2 \ to \ p_2^2\right)$ such that the equation (10).

$$p^x = p_1^v + w\left(p_2^v\right) \quad (10)$$

Here, $= 1 \ and \ -1$, and with 0 degrees and 180 degree phase shift of the second sub-block candidate signals. Thus, the maximum number of the possible candidate signal of OFDM signal is two-times the maximum number of the sub block candidate signals, which is ${AN}/{2}$. Finally, transmit signal has selected a lowest PAPR value by using clipping-SLM-PTS technique.

IV. RESULT AND DISCUSSION

The proposed Clipping-SLM-PTS technique is implemented using MATLAB (R2018a). The clipping-SLM-PTS technique is applied to the sub-blocks of un-coded information and that information is modulated by using QPSK modulation, and phase rotation factors are transmitted directly to the receiver through the sub-block in the OFDM system. The performance estimation was analyzed in terms of the Complementary Cumulative Distribution Function (CCDF) and the simulation parameters considered for performance analysis are IFFT length -1024, carrier Count -32 Bit Per Symbol =16, Symbol per Carrier -8. This research work considered 1000 samples for one sample period of time, which is denoted in time and frequency domain. These samples are further processed for block separating, parallel to serial conversion and transmission.

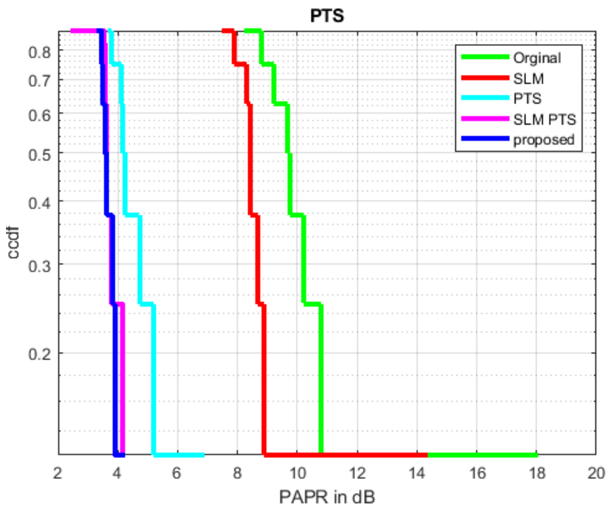

Fig. 2 Comparison of the existing and Clipping-SLM-PTS technique for IFFT length 1024

The Figure 2, 3, 4 and 5 shows the comparison of the existing and Clipping-SLM-PTS technique for different IFFT lengths: 1024 bits, 512 bits, 256bits and 128 bits. The maximum cycle of the SLM and PTS is 4 and 8 respectively. The above scenario is mentioned for 1024 IFFT symbols. If the length of IFFT has changed to different size of the samples like 512 bits, 256 bits and 128 bits. Figure 2 represents the comparison of PAPR reduction for existing and Clipping-SLM-PTS method. From the figure 2, it is clear that Clipping-SLM-PTS technique achieved 1.9dB of PAPR reduction and existing methods such as SLM, PTS, SLM-PTS techniques achieved 14.01 dB, 7.51 dB, 3.85 dB respectively. It clearly shows that the proposed Clipping-SLM-PTS technique performed well compared to the existing methods. Here, the maximum iteration of the PTS and SLM are 4 and 8 respectively.

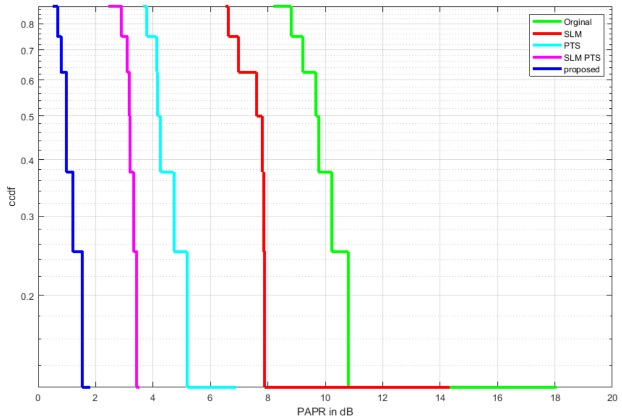

Fig. 3 Comparison of the existing and Clipping-SLM-PTS technique for IFFT length 512

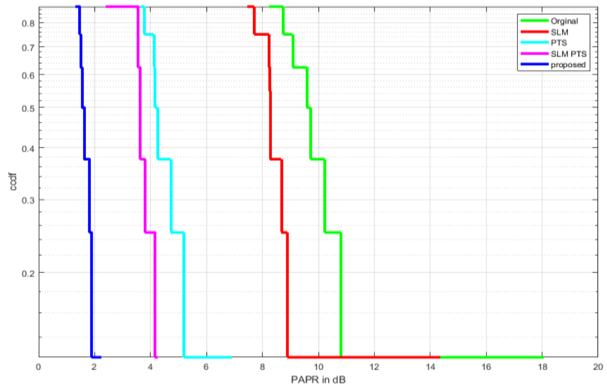

Fig. 4 Comparison of the existing and Clipping-SLM-PTS technique for IFFT length 256

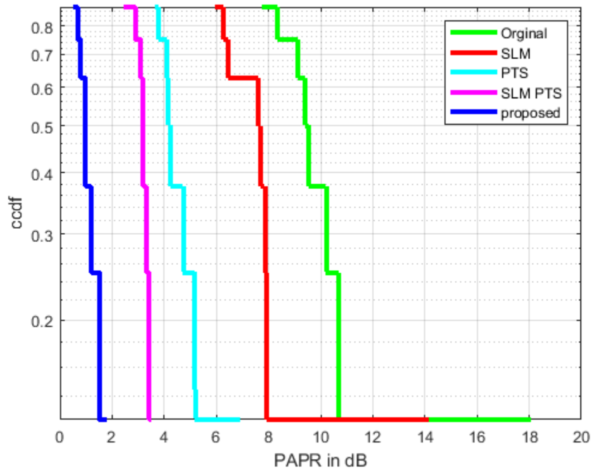

Fig. 5 Comparison of the existing and Clipping-SLM-PTS technique for IFFT length 128

Furthermore, the Clipping-SLM-PTS technique achieves 1.17 dB for 512 IFFT length, 1.95 dB for 256 IFFT length and 1.16 dB for 128 IFFT length, which is shown in the figure3, 4, and 5. From the figure, 2, 3, 4 and 5, it is concluded that the proposed clipping method significantly reduced the PAPR value compared to the existing methods. These figures clearly described that the PAPR value was reduced after applying less IFFT length. The 128 IFFT lengths give 1.16 dB in the PAPR reduction, which is the best PAPR reduction in the Clipping-SLM-PTS technique. Here, the sampling noise and the number of the signals reduced by using a clipping technique. Whereas, the computational complexity automatically reduced in the Clipping-SLM-PTS technique. The results confirmed that the IFFT length of 512 and 128 shows a significant output in PAPR reduction of the 1.17 dB and 1.16 dB.

V. Conclusion

Generally, high PAPR reduction is a significant challenging issue in the OFDM systems. The SLM and PTS are an efficient technique for PAPR reduction. PTS technique requires numerous reverse fast wavelets or Fourier changes, which results in increased high-computational complexity. Clipping-SLM-PTS technique has been proposed in this paper to diminish the computational complexity in the PTS and to reduce PAPR in OFDM system. The clipping technique has selected a limited number of the samples for minimizing the peak power in the OFDM system. The SLM technique selected a lowest PAPR for transmission. Finally, the phase factor value and number of transmitting sequence for the transmitted information were determined from the receiver in order to retrieve the original data. This clipping-SLM-PTS technique has provided the efficient results for different type of the IFFT length. In future work, the PAPR value in the OFDM system can be further reduced by using efficient PAPR reduction techniques.

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Mr. Lokesh C is a research student in SJB Institute of Technology, Bengaluru, India. And working as Assistant Professor in the department of Electrical and Electronics Engineering from Vidyavardhaka College of Engineering, Mysuru (India). His research mainly encompasses in the area of Wireless Communication, Application of Communication System in Electrical Engineering for Low Power Analysis. He has published 9 research papers in International Journals. And 6 papers in International Conference.

Dr. Rekha K. R. received PhD in the area of Electronics and Communication and working as Professor in the department of ECE at SJB Institute of Technology, Bangaluru, India. Her research area mainly consists of network design, high speed optical transmission, and