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Review on PAPR Reduction and Improvement of OFDM System Performance Using Artificial Intelligence Machine Learning Algorithm

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Abstract- The advancement of technology necessitates the development of more sophisticated modulation strategies for wideband digital communication systems. The requirements for high-speed data transmissions can be effectively met by utilizing orthogonal frequency division multiplexing, which is an effective technique. However, a high peak-to-average power ratio (PAPR) is one of the key limits that OFDM systems face, both in terms of their performance and their power efficiency. The evaluation of the PAPR reduction has become a topic of widespread interest in this present decade due to the relevance it holds in the industrial and scientific communities. The purpose of this study is to Review show the combination of the bat algorithm with the partial transmit sequence scheme as an effective way for reducing PAPR that also eases the burden of computing work. For the purpose of providing a comparative evaluation of the PAPR reduction performance, a number of simulations using various partial transmit sequence schemes have been carried out.

Index Terms- OFDM; Metaheuristic algorithm; PAPR; PTS.

I. INTRODUCTION

High data-rate is desirable in many recent wireless multimedia applications. Traditional single carrier modulation techniques can achieve only limited data rates due to the restrictions imposed by the multipath effect of wireless channel and the receiver complexity. In single carriers systems, as the data-rate in communication system increases, the symbol duration gets reduced. Therefore, the communication systems using single carrier modulation suffer from severe inter-symbol interference (ISI) caused by dispersive-channel impulse response, and thereby need a complex equalization scheme. Orthogonal Frequency Division Multiplexing (OFDM) is a potential candidate to fulfil the requirements of current and next generation wireless communication systems.

With the advent of new high data rate wireless applications, demand of the spectrum is rapidly increasing. Communications governmental and regulatory agencies impose regulations on spectrum usage, such as control of allocations and priorities, as well as its features. At this time, most of the prime spectrum has been assigned and it is difficult to find spectrum for the new wireless applications. It can be made available for either expand existing infrastructures or invent new services. Even though much of the spectrum has been allocated and preliminary measurement is that the spectrum is unutilized by primary users. There exist a lot of spectrums holes, which can be easily used by secondary users. The concept of dynamic spectrum access, where secondary users can borrow un-used portions of the spectrum from primary users. Cognitive Radio (CR) is employing on proper spectrum utilization because of their rapid adaptability and flexibility. Orthogonal Frequency Division Multiplexing (OFDM) is promising candidate for flexible spectrum pooling in communication systems.

Increasing the spectral efficiency of wireless communication systems is one of the greatest challenges faced by wireless communication engineers. The available bandwidth is scarce and costly, whereas, there is a huge demand for data rate created by increasing number of subscribers and increase in multimedia applications, which require large bandwidth. OFDM, with its spectrally efficient versions like MIMO-OFDM and multiple access versions like OFDMA are under active consideration to fulfil the requirements of present and next generation wireless systems.

High PAPR value in OFDM systems can reduce the Signal to Noise ratio of analog to digital converter (ADC) which in turn reduces the efficiency of Power Amplifier used in the transmitter. Hence reduction of PAPR is a potential area for research and by reducing the PAPR value, the battery life of systems used in broadband applications can be increased.

Even though the conventional PAPR reduction methods including

- Clipping and Filtering,
- Partial transmit sequence,

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- Selective mapping and Companding transform are effective they are computationally expensive.

Hence the recent solution to the PAPR problem with reduction in computational complexity is addressed using Neural network. However decreasing the mean square error of the OFDM symbol will have a significant impact in minimizing its PAPR value without compromising on BER performance. Moreover, the methods to minimize PAPR are significantly suggested by the researchers in the past, the computational complexity involved has a trade-off with the results achieved by the existing schemes.

II. PEAK-TO-AVERAGE POWER RATIO

PAPR occurs when, in a multi-carrier environment, the different sub-carriers are out of phase with each other. Thus, at each instant they are offset with respect to each other at different phase values. However, there may come a point when all of them achieve the maximum value simultaneously; this will cause the output envelope to suddenly shoot up. Thus, causes a 'peak' in the output envelope. Due to presence of large number of independently modulated sub-carriers in an OFDM system, the peak value of the system can be very high as compared to the average of the whole system. This ratio of the peak to average power value is termed as Peak-to-Average Power Ratio. Coherent addition of N signals of same phase produces a peak which is N times the average signal.

Disadvantages of High PAPR

Increased Complexity: Complexity is increased in the analog to digital and digital to analog converter.

Reduction in Efficiency of RF Amplifiers: This forces the power amplifier to have a large input back off and operate inefficiently in its linear region to avoid inter modulation products. When the OFDM signal with high PAPR passes through a non-linear device, (power amplifier working in the saturation region), the signal will suffer significant non-linear distortion. This non-linear distortion will result in in-band distortion and out-of-band radiation. The in-band distortion causes system performance degradation and the out-of-band radiation causes adjacent channel interference (ACI) that affects systems working in the neighbour bands. To lessen the signal distortion, it requires a linear power amplifier with large dynamic range. However, this linear power amplifier has poo efficiency and is also expensive.

Objectives

The major goal of this work is to suggest and concentrate on an effective hybrid technique for lowering PAPR while maintaining BER performance. A neural network-based module with simplified clipping and filtering has been proposed for this.

- To Analysis and applies NN to identify high PAPR sequence and observed BER parameter.
- To implementation of presented algorithm can reduce the calculation complexity of the PAPR reduction system to a great extent, which can be applied in the high speed data transmission scenario.

III. LITERATURE REVIEW

Ashish Goel et al. [1] Partial transmit sequence (PTS) is one of the well-known probabilistic schemes in reducing peak-to-average power ratio (PAPR) for orthogonal frequency division multiplexing (OFDM) signal. In our paper, we address the two major concerns of the PTS–OFDM system: side information (SI) free transmission from transmitter end and complexity reduction of the generated candidates. In the proposed scheme, side information is embedded on the locations of higher power subcarriers at specific partitions within the data block and at the receiver side extraction of SI is based on the power disparity among data symbols in the partitions. The error performance of the proposed scheme over the AWGN channel is analyzed mathematically. Besides, time efficiency of the proposed algorithm has been estimated in respect of computations required for finding the optimal candidates. Simulation results confirm that our proposed SI free transmission scheme performs well in terms of low BER degradations over the AWGN and Rayleigh fading channels, better SI error detection probability, lesser computations and improved PAPR reductions of the OFDM signals.

Yixuan Huang et al. [2] With the proliferation of internet of vehicles (IoV) applications, the information exchange and anti-collision radar become increasingly important for vehicular safety. The fusion of radar and wireless communication, called RadCom, has been proposed for future intelligent transportation. Traditional orthogonal frequency division multiplexing (OFDM)-based RadCom systems, however, suffer from impractical bandwidth allocation and high peak-to-average power ratio (PAPR), which results in not only severe nonlinear distortion but also low efficiency of high power amplifier (HPA). Motivated by these research problems, we propose a new partially-reserved cyclic algorithm for OFDM-based RadCom fusion systems. Our proposed RadCom algorithm is able to allocate appropriate communication bandwidth on the request of actural transmission by assuming that the entire bandwidth can be used for radar detection. In the frequency-domain, when the spectral sub-band for communication is reserved, we optimize over the remaining spectral sub-band by the proposed algorithm for PAPR reduction. The evaluation of the system with the proposed algorithm shows significantly improved performance over traditional OFDM-based RadCom systems in both the communication and radar functions when HPA is taken into account.

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Ghanbar Azarnia et al. [3] Orthogonal frequency division multiplexing (OFDM) has been proposed to achieve high data rate transmission in wireless communications. The OFDM system usually suffers from the high envelope fluctuations called peak-to-average power ratio (PAPR). The high PAPR causes a signal clipping distortion, and consequently, the performance is degraded. To mitigate the PAPR, we introduce a new PAPR reduction approach using a compressive sensing approach at the transmitter side and an orthogonal matching pursuit (OMP) reconstruction algorithm at the receiver end. Numerical results show the significant reduction of the PAPR compared with the traditional OFDM system without degrading the bit error rate performance.

S. Sengupta et al. [4] Orthogonal frequency division multiplexing (OFDM) is a widely used modulation and multiplexing technology applied in many telecommunications standards due to its spectral efficiency and robustness against multipath fading. The multicarrier aspect of OFDM signal is characterized by high peak-to-average power ratio (PAPR), which renders the power amplifier (PA) inefficient and causes distortion in the transmitted signal. Several techniques to overcome and reduce PAPR such as signal distortion, signal scrambling, coding etc. are proposed and implemented on multipath fading channels. Coding methods does not affect system complexity as forward error correction is an inherent block in any digital communication system. The frequency diversity benefits of OFDM is not utilized well unless channel coding is used. Several codes like Hamming, Golay, BCH, RS, Reed Muller etc. have been investigated so far. Goppa codes were needed to be explored in OFDM systems. In this paper, its ability to reduce the peak power is studied for conventional OFDM signal. These codes are used in computer and telecommunication based applications owing to its useful properties required for cryptography. The PAPR reduction of Goppa coded OFDM (GOFDM) is found to be satisfactory for higher order constellation mapping of binary information. A look up table can also be created to select Goppa code words on the basis of a desired threshold of PAPR in dB. A mathematical analysis of the relationship of input data and its PAPR is also executed and certain conclusions are drawn as shown in the lemmas. But coding methods solely cannot achieve substantial PAPR reduction and therefore most of the literature on PAPR reduction methods have combined coding with other techniques. In this paper, G-OFDM is extended to a hybrid method of constant amplitude modulated (CAM)-G-OFDM to completely mitigate the PAPR problem. But it is achieved at the cost of transmitter and receiver complexity and performance parameters like bit error rate (BER), dependency on modulation index etc. which can be taken care of by making some amendments in the system design.

Abbas Ali Sharifi et al. [5] Orthogonal frequency division multiplexing (OFDM) is extensively used in optical communications to achieve high rate transmission. In this paper, Vandermonde like matrix (VLM) pre-coding approach is offered to reduce the high peak-to-average power ratio (PAPR) of DC-biased optical OFDM (DCO-OFDM) and asymmetrically clipped optical OFDM (ACO-OFDM) signals in visible light communications. The proposed method is compared with Walsh–Hadamard transform (WHT), discrete cosine transform (DCT), and discrete Hartley transform (DHT) pre-coding approaches in terms of PAPR reduction performance. Simulation results indicate that the proposed method effectively reduces the PAPR of an optical signal in both DCO-OFDM and ACO-OFDM techniques.

Sandeep Bhad et al. [6] This paper focused on peak to average power ratio (PAPR) reduction scheme for OFDM system. OFDM has several properties which make it an attractive modulation scheme for high speed transmission. the main draw back of OFDM is high PAPR. The high PAPR causes the interference and degraded the performance of the system while OFDM signal pass through the amplifier. Here a simple scheme clip and filter is used to reduce the PAPR of OFDM system. Simulation results are show that the improvement in performance of OFDM system by reducing the PAPR using clip and filter scheme.

Sadhana Singh et al. [7] Like single-input single-output orthogonal frequency division multiplexing (SISO-OFDM), multi-input multi-output (MIMO) OFDM systems also suffer from the problem of high peak to average power ratio (PAPR). To account for this issue, amplitude clipping is one of the simplest techniques employed to reduce PAPR. However, it leads to additional distortion. In this paper, adaptive clipping technique is proposed to reduce PAPR of Alamouti coded MIMO-OFDM systems. In this scheme, successive peaks are clipped according to an adaptive algorithm. Simulation results reveal that the proposed clipping technique provides effective reduction in PAPR and better bit error rate (BER) performance. BER performance and PAPR reduction capability of the proposed algorithm in MIMO-OFDM systems are also compared with SISO-OFDM systems.

Mehdi Hosseinzadeh Aghdam et al. [8] Orthogonal frequency division multiplexing (OFDM) is a multicarrier modulation technique for high-speed data transmission in wireless communications. In an OFDM system, a large number of subcarriers are used to transmit the modulated symbols and consequently, the OFDM signals have a high peak-to-average power ratio (PAPR). To reduce the high PAPR, we propose a partial transmit sequence (PTS) method based on the adaptive particle swarm optimization. Also, the proposed method efficiently search the optimal combination of phase rotation factors to decrease the computational complexity. Experimental results show that the proposed method significantly has reduced the PAPR and computational complexity.

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M.V.R. Vittal et al. [9] In this paper, we propose a novel low complexity Partial Transmit Sequence (PTS) technique employing Random phase sequence matrix (RPSM) for peak to average power ratio (PAPR) reduction in orthogonal frequency division multiplexing (OFDM) systems. The main goal of our suggested scheme is to achieve the optimum phase sequence matrix to minimize PAPR and simultaneously reduce the computational complexity by decreasing the number of Inverse Fast Fourier Transform (IFFT) operations required. Lower PAPR reduces the complexity of Digital to Analog converters (DAC) and increases the efficiency of power amplifiers. Analytical expressions for Complementary Cumulative Distribution Function (CCDF), Number of subcarriers, subblocks and Total computational complexity are derived. Simulation results match closely with the analytical results. It is demonstrated that a favorable tradeoff can be achieved between the reduction of PAPR and computational complexity. It is observed that the suggested modified PTS technique outperforms the traditional PTS (T-PTS) technique.

Vaiyamalai Sudha et al. [10] Selected mapping (SLM) algorithm has been widely used for reducing high peak-to-average power ratio (PAPR) of orthogonal frequency division multiplexing (OFDM) signal. One of the factors affecting SLM performance is high computational complexity. To overcome this effect, in this paper, the time domain signals available at the output of IFFT blocks are separated into real odd, real even, imaginary odd and imaginary even subsequences using Fourier transform properties.
Jing Gao et al. [11] High peak-to-average power ratio (PAPR) is one of the major drawbacks in orthogonal frequency division multiplexing (OFDM) systems. Partial transmit sequence (PTS) is highly successful in PAPR reduction, but the considerable computational complexity for exhaustive search over all combinations of allowed phase factors is potential problem for a practical implementation. In this paper, the harmony research algorithm is applied to search the optimal combination of phase factors, which can significantly reduce the computational complexity and offers lower PAPR at the same time. complexity.

Summary
OFDM is a promising technique for very high speed communication systems as it offers spectral efficiency and reduces intersymbol interference. But OFDM has inherent drawback of high PAPR due to a large number of subcarriers .Various methods have been proposed for reduction of PAPR of OFDM signal. The simplest method is clipping but it introduces noise for large clipping ratio. PTS and SLM give good performance but require extra information for reception. Modified SNT do not need any side information but PAPR reduction needs to be enhanced. In future we improve BER(Bit Error Rate) and proven that PTS is better than SLM technique so that System exhibits good performance in terms of BER using PAPR reduction technique

V. PROBLEM IDENTIFICATION

High PAPR and inter carrier interference (ICI) are the two major issues in the implementation of an OFDM system. The synopsis aims at exploring and arriving at efficient, low complexity schemes for PAPR reduction in OFDM based systems (with and without ICI cancellation) of practical use. The first problem addressed in this thesis is the high PAPR of an OFDM signal.

We begin by exploring the existing PAPR reduction techniques and to find out their advantages and major limitations for implementing a practical OFDM system. Investigation of efficient PAPR reduction schemes for an OFDM system is thus considered as one of the problem areas explored in this synopsis. Being a multicarrier modulation scheme, OFDM brings all major benefits of a multicarrier scheme but unlike single carrier modulation schemes, it suffers from the problem of ICI. In this synopsis, we explore the existing ICI cancellation schemes and perform a comparison of BER performances. As discussed above, the PAPR is an important parameter that must be taken into consideration while designing an ICI cancellation scheme for the OFDM system of practical use. Therefore, investigation of PAPR performance of OFDM systems utilizing ICI cancellation schemes is also considered as another area to be explored in this thesis. Final aim of this synopsis is to suggest a joint scheme for simultaneous PAPR reduction and ICI cancellation in OFDM systems.

VI. CONCLUSION

This paper has provided a comprehensive overview of the techniques used in the literature for reducing the PAPR in OFDM systems. We discussed various traditional approaches, novel schemes, and emerging trends in the field. The literature review revealed that conventional techniques, such as PTS Partial transmit sequence, SLM Selected mapping, and clipping, among other techniques, have been widely studied and utilized for PAPR reduction in OFDM. These methods have shown significant improvements in reducing the PAPR. However, they often come with certain drawbacks, such as increased complexity, BER Bit error rate, and distortion. One of the notable advancements in recent years is the integration of ML Machine learning techniques for PAPR reduction. ML-based approaches have shown great potential in addressing the challenges associated with the PAPR in OFDM systems. These methods leverage the power of data-driven learning and optimization to adaptively and intelligently reduce the PAPR while preserving system performance.

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