A REVIEW PAPER WORK ON NOVEL TONE INJECTION SCHEME FOR PAPR AND PICR REDUCTION OF OFDM SIGNAL

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Abstract---*The communication industry is the biggest industry in the 21st century with applications like mobility, radar, satellite, marine, etc. The wireless communication has attained the 75% share of entire communication industry with applications like 3GPP, 4G, Wi-Fi and Wimax. The implementation of the orthogonal frequency division multiplexing (OFDM) in a wireless communications domain has introduced the world a new communication model which can offer 100 Mbps speed with minimum disadvantages. The transmit signals in an orthogonal frequency-division multiplexing (OFDM) system can have high peak values in the time domain since many subcarrier components are added via an inverse fast Fourier transformation (IFFT) operation. In this paper, a novel TI scheme that uses the clipping noise to find the optimal equivalent constellations is proposed. We first take all the samples of original signal higher than the PAPR threshold as the clipping noise, and then minimize the mean squared error of this noise and possible equivalent constellations to determine the optimal size and position of the constellations. In addition, by applying the proposed TI scheme to two special constellation extension, the inherent power increase in TI scheme can effectively be reduced or avoided. A thorough research work based on the PAPR reduction techniques is discussed in depth for better understanding and analysis. Simulation results confirm that both the proposed PAPR and RMS-PICR reduction schemes can dramatically reduce the computational complexity while maintaining a good system performance.*

Keywords: OFDM, PAPR, PICR, IFFT, TI

1. INTRODUCTION

Communication industry has grown enormously in the past six decades and supports various applications belong to different research fields. Wireless communication is a major constituent of communication industry which has 75% of total market share. Wireless communication takes the communication domain to the next level in terms of reliability and performance. Mobile data transmission is considered as a 21st century system which offers higher data rate but suffers from complexity. It is well known that there is unmanageable growth of users in telecommunication industry. So the user's requirements become high for ubiquitous access, high data rate. Therefore, energy consumption in wireless communication has been increasing. As a result, CO2 is emitted which makes the atmosphere polluted and become an obstacle in the development of wireless communication. According to Survey, ITU has submitted that the ICT industry produces 2% - 2.5% of total greenhouse gas emission. That includes PC 40%, data centers 23%, telecommunication 24% and printers 6%. So, out of all we are concentrating on telecommunication to reduce emission of CO2. So to overcome this emission in telecommunication, energy efficiency has become a global trend in future wireless telecommunication networks.

OFDM is known as multiplexing/modulation scheme and it acts on the "orthogonality principle". OFDM offers high data and supports advance applications. Although OFDM have advantages over traditional communication models frequently suffer from timing jitter, relative fading, distortion and PAPR. The presence of PAPR results in Gaussian distributed output samples in OFDM. Inter-modulation among sub-carriers and undesired Out-of-Band Interference (OBI) are the resultant of PAPR. PAPR presence has been an area of concern in OFDM and vast amount of research has been carried out using different techniques like Clipping and Filtering (CF), Tone Reservation (TR), Companding Transform (CT), etc. But none of the above techniques succeed in achieving the desired result. Clipping and filtering technique architecture remains easy to tackle the issue of PAPR but presence of significant OBI, in-band distortion and nonlinear processing make this technique unused in real time. Compared to in-band distortion, OBI is more critical because it severely interferes with the radio communications in adjacent channels.

2. ORTHOGONAL FREQUENCY DIVISION MULTIPLEXING (OFDM)

Orthogonal frequency division multiplexing (OFDM) and compatible usage in wireless standards like DVB, WIMAX, IEEE802.11a and LTE has been gained interest from worldwide research organizations. Recently an international meeting has conducted in order to discuss importance of orthogonal frequency division multiplexing (OFDM) and its usage in advance wireless standards makes Orthogonal frequency division multiplexing (OFDM) as an emerging technology to meet the requirements in practical scenario. Orthogonal frequency division multiplexing (OFDM) has high data rates compared to traditional communications systems and it suited well for frequency selective channels. Large delay spreads is a drawback which commonly occurs in the high speed wireless communication system and orthogonal frequency division multiplexing (OFDM) modulation scheme has ability to transform the wide frequency selective channel to narrow ones which creates the robust environment to resists against occurrence of the large delay spreads and preserves the Orthogonality in a perfect way in the frequency domain. Orthogonal frequency division multiplexing (OFDM) has one more unique advantage to reduce the complexity in the system by introducing the cyclic prefix at the transmitter end and performing scalar equalization at the receiver end in the wireless standards like WIFI and WIMAX.

In 21st century, the role of the technology to offer high data rates and mobility is crucial and the technology is changing its face every other because of immense research work carried out on the advance wireless communications. Actually the research on parallel data transmission is traced out in the mid 1960's but it takes 25 long years to make it compatible to real time applications. The OFDM gradually seen its presence in the various application and now various international standards consider it as promising modulation scheme which initially supports wireless standards like WIFI, WIMAX, LTE etc. The two important parameters required better transmission of data from one entity to another are data rate and the modulation scheme should support different channel conditions to obtain better spectral efficiency.

The evolution of the third Generation Partnership Project (3GPP) development based on the Long term evolution (LTE) supports two networks namely Radio access network (RAN) and core network. The transformation of the 3G to 4G observes the changes in terms of data rate and spectral efficiency. International Telecommunication Union Radio communication Sector (ITU-R) initialized a set of requirements for the 4th generation cellular system and requirement of the high data rate is specified by International Mobile Telecommunications Advanced project (IMT-Advanced) for 4G. OFDM is a modulation scheme which is one of the techniques employed in LTE to enhance the data stream.

3. RELATED WORK

Companding is another popular distortion based scheme for PAPR reduction in OFDM system. In [5], Wang et al. proposed a scheme based on μ-law companding to reduce the PAPR of OFDM signal. In μ-law companding scheme the peak value of the OFDM signal before and after companding remains same, which keeps peak power of the OFDM signal unchanged but the average power of the OFDM signal after companding increases and therefore the PAPR of the OFDM signal gets decreased. But due to increase in the average power of the OFDM signal the error performance of μ-law companding scheme degrades. Jiang et al. proposed exponential companding (EC) function [6] to transform Rayleigh distributed magnitude of OFDM signal to a uniformly distributed OFDM signal using an exponential function and this scheme is known as "Exponential Companding" scheme. Exponential companding scheme can effectively reduce the PAPR of the OFDM signal but its BER performance also degrades with PAPR reduction.

Huang et al. proposed four companding transformation functions [7] to reduce the PAPR of the OFDM signal, which includes: linear symmetrical transform (LST), linear non symmetrical transform (LNST), non-linear symmetrical transform (NLST) and non-linear nonsymmetrical transform (NLNST). It has been shown that LNST performs the best among four companding function [7]. In LNST an inflexion point is introduced to treat large and small signals on different scale to achieve better BER and PAPR performance. Linear companding transform (LCT) [8] has been proposed by Aburakhia et al. to

reduce the PAPR of the OFDM signal. LCT also treats large and small signals on different scale but has two inflexion points to achieve more flexibility in designing the companding function. The abrupt change in the transformed signal at inflexion point degrades the power spectral density (PSD).

Trapezoidal companding (TC) [9] proposed by Hou et al. is an efficient method to reduce the PAPR of OFDM signal with low BER. TC [10] transforms the Rayleigh distributed magnitude of original OFDM signal to a trapezoidal distribution and called "Trapezoidal Companding". Trapezoidal companding utilizes a piecewise function defined in three intervals of OFDM signal magnitude. Jeng et al. proposed [11] trapezium distribution based companding (TDBC) to transform the Rayleigh distribution of original OFDM signal to biased linear distribution called "Trapezium distribution". All the companding schemes [5] [11] distort the shape of the original OFDM signal and PAPR reduction capability is achieved at the cost of BER performance degradation. Non-distortion PAPR reduction schemes do not distort the shape of the OFDM signal and therefore no spectral regrowth takes place.

Coding technique [2] is one of the simplest non-distortion PAPR reduction schemes, which can be applied for reducing the PAPR of OFDM signal. But these type of schemes result in significant loss of data rate in OFDM system. Two more distortion-less PAPR reduction techniques namely partial transmit sequence (PTS) [12] and selective mapping (SLM) are also proposed in the literature. In PTS scheme all the subcarriers are partitioned into multiple disjoint sub blocks and then each of the sub blocks is multiplied by a set of rotating phase factors and combined to achieve a signal with lowest PAPR. In SLM, parallel data signal of length N is multiplied by a predetermined set of U phase vectors of length N and generates U alternative signals. Out of U alternative signals, one of them with the least PAPR is selected for transmission. In both of the schemes the information about the phase factors by which these sub blocks/data symbols are multiplied, needs to be conveyed to the receiver and it is known as side information (SI). The SI has the highest importance because it is used to recover the original data signal. If SI gets corrupted then entire OFDM symbol block can be damaged and error performance of SLMand PTS-OFDM system degrades severely. In PTS technique, if the number of sub blocks increases then it not only increases computational complexity for selecting the optimum set(provide least possible PAPR) of phase sequence but also increases the amount of SI to be conveyed to the receiver. The SI results loss of data rate in OFDM system. Similarly in SLMOFDM systems as the number of alternative OFDM signal increases, the number of bits required to encode the side information also gets increased, which results in data rate loss. The SI bits are extremely important for data recovery and it may be necessary to allocate few redundant bits to ensure accurate recovery of SI, but this operation will further increases the loss of data rate in OFDM system.

Many schemes for embedding the SI have been proposed in [13] for PTS-OFDM systems. In [14] many SI embedding schemes have been proposed for SLM-OFDM system. These schemes [13] embed SI in the OFDM signal without using any extra bit. At the receiver, SI is extracted from the received OFDM signal, and decoded to obtain the information about the phase factor used at the transmitter to minimize PAPR. The demodulated signal is multiplied by the reciprocal of recovered phase factors, due to which the computational complexity at the receiving end gets increased. In many of the SI embedding schemes, the SI detection at lower values of SNR is very poor, due to which error performance of the OFDM system degrades severely.

Existing SI embedding schemes [13] eliminates the requirement of SI transmission but these suffer from one drawback or the other, whether in terms of computational complexity, poor PAPR reduction capability or incorrect SI detection. In [15], Zhou et al. proposed MPSM-PTS scheme which extends the QPSK constellation points to disjoint points of 16-QAM constellation and eliminates the requirement of side information. The MPSM-PTS scheme [15] is completely free from SI, i.e. extraction of SI from the received signal is not required. Hence the receiver structure of the scheme proposed in [15] is computationally less complex.

In wireless standards like LTE, OFDM is used in downlink, where mobile station acts as receiver. The mobile stations have limited computational resources; therefore, a PAPR reduction scheme with less

computational complexity at receiving end will be more beneficial. As discussed above, the schemes proposed in [13] have computationally complex receiver in comparison to the schemes proposed in [13]. Hence, MPSM-PTS scheme is a viable choice for PTSOFDM system.

As discussed earlier, OFDM system is very sensitive to small carrier frequency offset; a small carrier frequency offset in between transmitter and receiver carrier frequencies can disturb the orthogonality of the subcarriers and causes ICI. The ICI interference degrades the overall performance of the OFDM system. It is generally characterized by carrier to interference ratio (CIR). Various ICI cancellation techniques have been proposed in the literature to eliminate the effect of ICI, these include ICI self-cancellation, New ICI self-cancellation, General ICI self-cancellation scheme, ICI conjugate cancellation scheme, General phase rotated conjugate transmission ICI cancellation scheme etc.

In [16] Zhao and Haggman proposed an ICI cancellation scheme called “ICI self cancellation” to combat the effect of ICI. In this scheme the data symbols are repeated on multiple adjacent subcarriers using polynomial coding but it results in PAPR performance degradation. The CIR performance of ICI self cancellation can be further improved by the scheme [17] proposed by Santhananthan et al. and called “New ICI self-cancellation scheme”. In this scheme [17] data symbols are repeated symmetrically using polynomial coding, which achieves frequency diversity effect of multipath fading channel. The CIR and the BER performance of ICI cancellation schemes [16], [17] are claimed to be further improved by General ICI cancellation scheme, proposed by Seyedi et al., which is based on windowing technique used at the transmitter and receiver of OFDM system.

4. CONCLUSION

The proposed method clipping noise based Tone Injection (TI) scheme gives excellent performance for reduction of PAPR in OFDM as well as it reduces the computational complexity of system. Here considerations of nearest equivalent constellations is there to get an optimal solution of equivalent constalltions.Also, requirement of FFT’s also reduced so as to reduce computational complexity. Again to get better BER performance we are going for PICR reduction in TI scheme. By simulation results we proved that we are getting very less PAPR and PICR values as well as computational complexity is reduced compared to other methods. A indepth research work is discussed in this paper for better analysis and projection of past works reported on the PAPR in literature.

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REFERENCES

[1] “An Investigation of Peak-to-Average Power Reduction in MIMO-OFDM Systems”,Wang Yi Gu linfeng Blekinge Institute of Technology October 2009.

[2] 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.

[3] Zhou, Y. , Jiang, T., “A Novel Multi-Point Square Mapping Combined with PTS to Reduce PAPR of OFDM Signals without Side Information”, IEEE Transaction on Broadcasting, Vol. 55, No. 4, pp. 831– 835, Dec. 2009.

[4] Armstrong, J., “Peak-to-average power reduction for OFDM by repeated clipping and frequency domain filtering,” Electronics Letters, vol. 38, No. 5, pp. 246– 247, Feb. 2002.

[5] Wang X. B., Tjhung T. T., Ng C. S., "Reduction of peak-to-average power ratio of OFDM system using a companding technique", IEEE Transaction on Broadcasting, vol. 45, No. 3, pp. 303–307, Sept. 1999.

[6] Jiang T., Yang Y., Song Y., "Exponential companding transform for PAPR reduction in OFDM systems", IEEE Transaction on Broadcasting, vol. 51, No. 2, pp. 244– 248, June 2005.

[7] Huang J. L., Zheng J., Letaief K. B., Gu J., "Companding Transform for Reduction in Peak-toAverage Power Ratio of OFDM Signals", IEEE Transaction on Wireless Communications, Vol. 03, No. 6, pp. 2030-2039, November 2004.

[8] Wang C. L., Huang Y. C., "Intercarrier interference cancellation using general phase rotated conjugate transmission for OFDM systems", IEEE Transaction on Communications, Vol. 58, No. 3, March 2010.

[9] L. j. Cimini jr "Analysis and simulation of a digital mobile channel using orthogonal frequency division multiplexing," IEEE Transactions communication, vol. 33, pp. 665-675, July 1985.

[10]Hou, J., Ge J. H., Li J., "Trapezoidal companding scheme for peak-to-average power ratio reduction of OFDM signals," Electronics Letters, Vol. No. pp 1349 – 1351, Dec.2009.

[11]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.

[12]Muller, S. H., Huber, J. B., "OFDM with reduced peakto-average power ratio by optimum combination of partial transmit sequences", Electronics Letters, Vol. 33, No. 5, pp. 36–69, Feb. 1997.

[13] Jayalath A. D. S., Tellambura C., "SLM and PTS peakpower reduction of OFDM signals without side information," IEEE Transaction on Wireless Communication., Vol. 4, No. 5, pp. 2006–2013, Sep. 2005.

[14]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.

[15]Zhou, Y. , Jiang, T., "A Novel Multi-Point Square Mapping Combined with PTS to Reduce PAPR of OFDM Signals without Side Information", IEEE Transaction on Broadcasting, Vol. 55, No. 4, pp. 831– 835, Dec. 2009.

[16]Zhao Y., Häggman S. G., "Intercarrier interference selfcancellation scheme for OFDM mobile communication systems," IEEE Transaction on Communications, Vol. 49, No. 7, pp. 1185-1191, July 2001.

[17]Sathananthan K., Rajatheva, R. M. A. P., "Analysis of OFDM in the presence of Frequency Offset and a method to reduce performance degradation", Proc. of Global telecommunications conference'00, San Francisco, USA, Vol. 1 pp.72-76, Nov. 2000.