PAPR Reduction Using Pre-Coder Based Discrete Hartley Transform in Optical OFDM Systems

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ABSTRACT:

In many wireless network applications Optical Orthogonal Frequency Divison Multiplexing (O-OFDM) plays an important role. It is a promising modulation technique for handling rapidly growing internet traffic. But higher peak to average power ratio (PAPR) is a major drawback in O-OFDM systems, which in results increases the complexity of digital to analog converters (DAC) and analog to digital converters (ADC) and also degrades the efficiency of high power amplifiers (HPA). Here in this letter we introduced a novel PAPR reduction technique using pre-coding matrix based discrete Hartley transform (DHT). The proposed scheme uses M-ary quadrature amplitude modulation (QAM) (where M=4, 8, 16... 256) and it gives the better performance than the DCT pre-coded technique and original OFDM system.

Keywords: Optical OFDM, PAPR, QAM, DCT and DHT

I.INTRODUCTION:

Due to the multipath fading effect and receiver complexity of wireless channels, the traditional modulation techniques which are based on single carrier can achieve limited data rates. High data-rate is desirable in many recent wireless multimedia applications [1]. However, 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, thereby needing a complex equalization mechanism. Optical Orthogonal Frequency Division Multiplexing (O-OFDM) is a special form of multicarrier modulation technique, in which the total frequency selective fading channel will be divided into many orthogonal narrow band flat fading sub channels. In O-OFDM

system high-bit-rate data stream is transmitted in parallel over a number of lower data rate subcarriers and do not undergo ISI due to the long symbol duration[2]. Major advantages of O-OFDM systems are

» High spectral efficiency

» Simple digital realization by using the FFT operation

» Due to the ISI avoidance, the complexity in the receiver will be reduced

» Various modulation schemes will be used to achieve the best performance of the system

Due to the above mentioned advantages, O-OFDM has been used in many wireless applications such as Wireless Personal Area Network (WPAN), Wireless Local Area Network (WLAN) [4], Wireless Metropolitan Area Network (WMAN), Digital Audio Broadcasting (DAB) [3] and Digital Video Broadcasting (DVB) [5]. It is also being considered for IEEE 802.20, 802.16 [6], [7] and 3GPP-LTE. With the use of cyclic prefix for eliminating the effect of ISI, there is a need for a simple one tap equalizer at the O-OFDM receiver. It brings in unparalleled bandwidth savings, which leads to high spectral efficiency. Despite the widespread acceptance of O-OFDM, it has its drawbacks:

» O-OFDM signals with high peak-to-average power ratio (PAPR) leads to the degradation in system performance, which in results the enhanced out-of-band power.

» O-OFDM systems are more sensitive to Doppler spread when compared to single carrier modulation schemes.

» The system performance will be degraded by the phase noise, which is caused by the imperfections of the transmitter and receiver.

» It requires accurate time and frequency synchronization.

» Due to the cyclic prefix (CP) it loses spectral efficiency

As listed above, large envelope fluctuation in O-OFDM signal is one of the major drawbacks of O-OFDM. Such fluctuations create difficulties because practical communication systems are peak power limited. Thus, envelope peaks require a system to accommodate an instantaneous signal power that is larger than the signal average power, necessitating either low operating power efficiencies or power amplifier (PA) saturation.

In order to amplify the O-OFDM signal with large envelope fluctuations, PAs with large linear range are required, which makes it very expensive. If PA has limited linear range then its operation in non linear mode introduces out of band radiation and in band distortion. It is also necessary to have D/A and A/D converters with large dynamic range to convert discrete time O-OFDM signal to analog signal and vice versa.

II. LITERATURE SURVEY:

From the past decades many PAPR reduction techniques have been proposed to improve the digital communication system efficiency, and still the researchers are focusing on developing extended PAPR reduction schemes with more effective results. Among them, few techniques like block coding schemes [8], Tone Reservation (TR), Tone Injection (TI) [10-12], iterative clipping and filtering [16], Partial Transmit Sequence (PTS) [9], Active Constellation Extension (ACE) [11], Adaptive ACE [12-14], Select Level Mapping (SLM) [19], companding techniques such as linear [10], non-linear, exponential companding [15] are more popular.

The letter proposed in [8] gives a block coding technique for PAPR reduction of multi carrier transmission methods such as O-OFDM. In this approach the author has used ¾ rate block code and simulated this with an example of four- carrier signal and also with eight-carrier signal.

However, block coding scheme has got reduced peak to mean envelop power ratio (PMEPR) but it has the limitation in number of carriers, hence does not suit for longer data sequences. X. Li et. al. in [9] proposed a new PAPR reduction scheme which is based on clipping and filtering, which reduces the peak to mean envelop power ratio by clipping the transmitted sequence to certain extent and afterwards filters the clipped data to reduce the PAPR. Although it reduces the PAPR to some extent but while clipping the input data we are losing the original data bits, which in results the poor system efficiency. Wattanasuwakull et. al.

proposed tone reservation (TR) and tone injection (TI) method [10] to reduce the PAPR of the O-OFDM signal. Main idea of the approach in [11] is to produce a surplus and linear signal which will reduce the peak-power by reservation of number of subcarriers. However, due to the surplus symbols and the larger signal constellation usage it slows down the data rate and increases transmitter power. Sang et. al. in [13] proposed a modified selective mapping scheme (SLM) to reduce the PAPR which performs better than conventional SLM and PTS. Algorithm in [13] proposes a modified SLM in which the subcarriers which are predefined will be inserted by the dummy or complementary sequence taken from flipping method.

Partial Transmit Sequences (PTS) is an efficient technique for reduction of Peak-to-Average Power Ratio (PAPR) Orthogonal Frequency Division Multiplexing (OFDM) system. However, higher computational complexity is the major drawback of PTS. In order to overcome this many PTS methods have been proposed. The paper proposed in [14] discusses the optimized PTS (O-PTS) scheme with super imposed training, in which the O-PTS method reduces the PAPR to 7.25 dB from 10 dB of conventional PTS scheme.

In [15] transformation based approach for PAPR reduction has been proposed, which uses linear companding transform. Another approach of PAPR reduction proposed in [16], which presents a new hybrid peak-to-average power ratio reduction technique with the combination of ACE and TR. Recently, adaptive active constellation extension (AACE) method has been proposed in [17-18]. In this approach AACE overcomes the drawbacks of the existed ACE and clipping based active constellation extension (CB-ACE).

In [20] the author tried to explain the companding OFDM techniques to reduce the PAPR. Companding techniques have got the better performance than the ACE, AACE but it supports limited modulation schemes and it suffers from large degree of companding value However, all the methods which have been discussed above have many drawbacks. To overcome all the drawbacks of conventional schemes here in this paper we introduced a novel scheme which is based on pre-coding matrix Discrete Hartley Transform (DHT). This technique is efficient, signal independent, distortion less, it does not require any optimization algorithm and PAPR is completely eliminated.

III. PROPOSED DHT TECHNIQUE:
A. PAPR in OFDM Systems :

Input data sequence to be transmitted with N subcarriers in an OFDM symbol is (0),X(1), • • •,X(N -1). The baseband representation of the OFDM symbol is given by:

$$x(t) = \frac{1}{\sqrt{N}}\sum_{n=0}^{N-1} X(n)e^{\frac{j2\pi nt}{N}} \qquad 0 \le t \le T \quad (1)$$

T is OFDM symbol duration. When N value will be increased then both the real and imaginary parts of x(t) would become Gaussian distributed and each with zero mean with a variance of $E[|x(t)^2|]/2$, and the OFDM symbol amplitude follows a Rayleigh distribution. Therefore, it is possible that the OFDM symbol amplitude will be exceeds than the maximum amplitude. Practical hardware such as A/D and D/A converters, high power amplifiers (HPA) has finite dynamic range; therefore the maximum amplitude of OFDM signal should be limited.

PAPR of an OFDM signal has been defined as:

$$PAPR = \frac{max[|x(t)^2|]}{\frac{1}{T}\int_0^T |x(t)|^2 dt} \qquad (2)$$

In dB value the PAPR can be written as $PAPR=10\log_{10}$ (PAPR). It is easy to see from (2) that reduction of PAPR can be achieved by reducing the numerator and increasing the denominator, or both.
Complementary cumulative distributed function (CCDF) will be used as a measurement of PAPR effectiveness, which is the probability that PAPR exceeds some threshold, i.e.,
CCDF=Probability (PAPR>p_0)   (3)
where p_0 is the threshold.

B. DCT Pre-coded Technique:

The DCT-pre coded optical fast OFDM system (DCT-pre coded FOFDM), which applies the DCT before the inverse DCT (IDCT) rather than the DFT to spread data into all the subcarriers. By spreading the data, the PAPR of the proposed FOFDM system can be reduced in comparison with that of the conventional FOFDM system, and DFT-spread OFDM system. Therefore, it is expected that the PAPR reduction of the proposed FOFDM system will help achieve a superior nonlinear tolerance in optical fiber channels in comparison with the conventional FOFDM system.

C. Pre-coding Discrete Hartley Transform:

Generally, the DHT is an invertible function H: Rn -> Rn (where R denotes the set of real numbers) and it is a linear function. The N real numbers x0, …., xN-1 are transformed into the N real numbers H0, …, HN-1.
The Pre-coding matrix P can be written as

$$P = \begin{bmatrix} p_{00} & p_{01} & \cdots & p_{0(N-1)} \\ p_{10} & p_{11} & \cdots & p_{1(N-1)} \\ \vdots & \vdots & \ddots & \vdots \\ p_{(N-1)0} & p_{(N-1)1} & \cdots & p_{(N-1)(N-1)} \end{bmatrix}$$

Where P is a Pre-coding Matrix of size N×N is shown in above equation. The complex baseband OFDM signal with N sub carriers can be written as

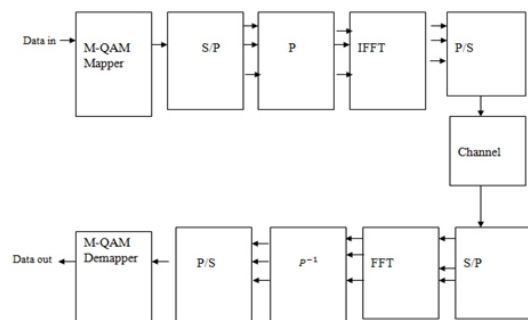$$x(t) = \frac{1}{\sqrt{N}}\sum_{k=0}^{N-1} P.X_k \, e^{j2\pi k\Delta ft}, \qquad 0 \le t \le NT \quad (8)$$

Fig.1 Pre-coding matrix based OFDM system

We can express modulated OFDM vector signal with N subcarriers as follows:

$$x_N = IFFT\{P.X_N\} \qquad (9)$$

The DHT is a linear transform and N-point DHT can be defined as:

The DHT is a linear transform and N-point DHT can be defined as:

$$H_k = \sum_{n=0}^{N-1} x_n \left[\cos\left(\frac{2\pi nk}{N}\right) + \sin\left(\frac{2\pi nk}{N}\right) \right] \quad (10)$$

$$= \sum_{n=0}^{N-1} x(n).cas\left(\frac{2\pi nk}{N}\right)$$

Where $cas\,\theta = cos\theta + sin\theta$ and $k = 0, 1, \dots N-1$

$$p_{m,n} = cas\left(\frac{2\pi mn}{N}\right) \quad (11)$$

P is pre-coding matrix of size N×N. and both (m, n) are integers from range 0 to N-1. The DHT is also invertible transform which allows us to recover the X_n from H_k and inverse can be obtained by simply multiplying DHT of H_k by 1/N.

IV.SIMULATION RESULTS :

Experimental results have been done in MATLAB 2014a version with 4.00 GB RAM and i3 processor for decreasing the CPU time to execute the MATLAB code for this project. Here, in the fig. 2 (a) we had compared the precoder based PAPR reduction techniques such as DFT, DCT, Walsh Hadamard transform (WHT) and with proposed technique, it shows that the DF transform got 4.35 dB, WH transform got 3.25 dB and 12 dB for original OFDM system, and the DCT reduced the PAPR up to 2.85 dB, where the proposed scheme has reduced it to 2.69 dB. In fig.3, we analyzed the bit error rate (BER) performance of various levels of modulation schemes like QAM and QPSK. Here we used M-ary modulation techniques such as 4-QAM, 4-QPSK, 8-QAM and 8-QP-SK and also 16-QAM with 16-QPSK.
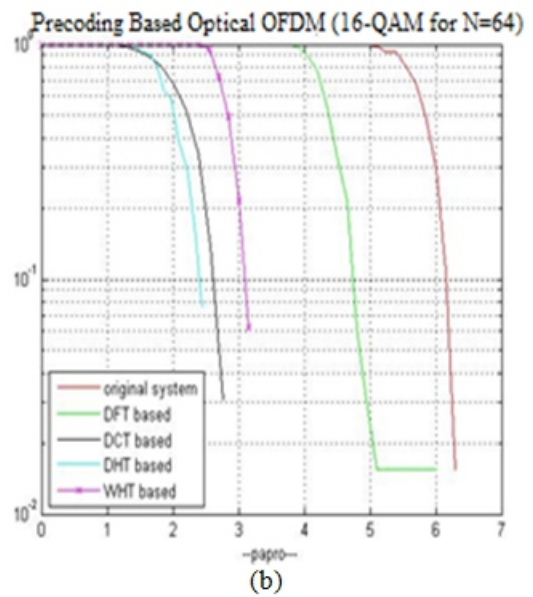

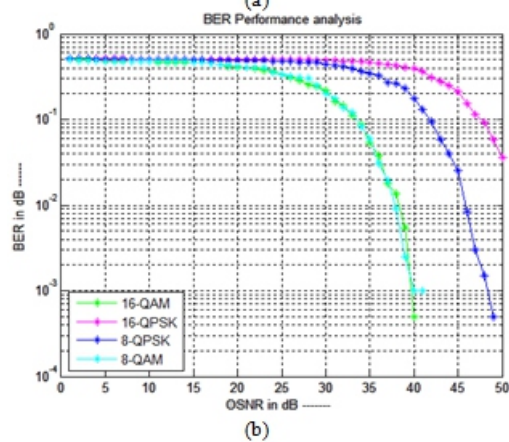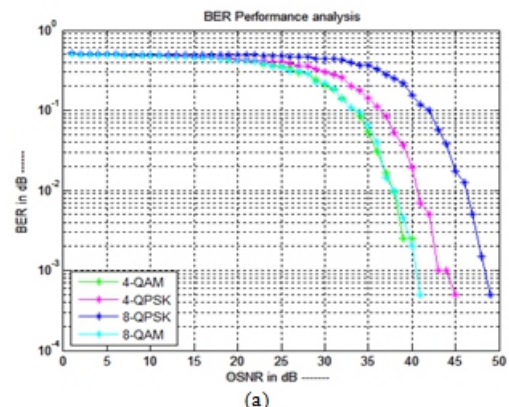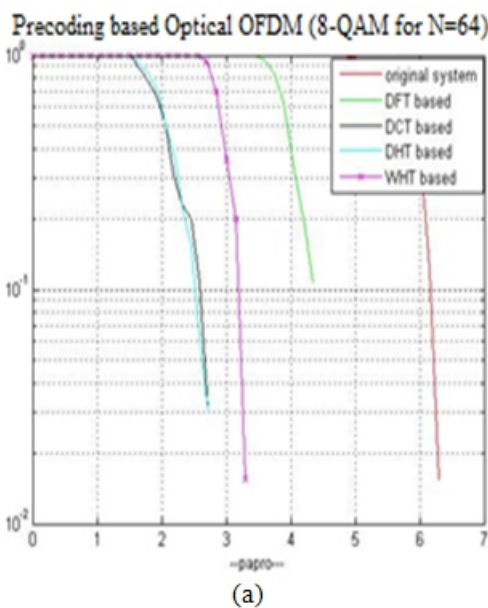Fig.2 (a), (b) PAPR analysis of proposed and existing schemes.

Fig.3 (a) BER performance of different modulation schemes

V.CONCLUSION:

In this letter, we analyzed the performance of Pre-coding matrix DHT for the reduction of PAPR in high speed OFDM systems using M-QAM constellation modulation scheme (where M=16, 32, 64, 128 and so on). The simulation results which have been executed in MATLAB shows that the proposed pre-coding DHT OFDM System has got the better performance than the conventional schemes such as Original pre-coded system, Companding scheme, exponential companding and without companding OFDM systems respectively.

Thus, it is concluded that proposed system shows better PAPR reduction than conventional reduction techniques. Additionally, it does not require any power increment, complex optimization and side information to be sent for the receiver.

REFERENCES:

1.Wu Y., W. Y. Zou, "Orthogonal frequency division multiplexing: A multi-carrier modulation scheme," IEEE Transactions on Consumer Electronics, vol. 41, no. 3, pp.392–399, Aug. 1995.

2.Van Nee R., Prasad R., OFDM for wireless Multimedia Communications, Artech House, 2003.

3.ETSI, "Radio broadcasting systems; Digital Audio Broadcasting (DAB) to mobile, portable and fixed receivers", European Telecommunication Standard, Standard EN-300401, May 1997.

4.Hiperlan2, "Broadband Radio Access Networks (BRAN), HIPERLAN Type 2; Physical (PHY) layer", ETSI, Tech. Rep., 1999.

5.ETSI, "Digital Video Broadcasting (DVB); Framing structure, channel coding and modulation for digital terrestrial television", European Telecommunication Standard, Standard EN-300-744, 2004-2006.

6.Part 16: Air Interface for Fixed Broadband Wireless Access Systems Amendment 2: "Medium Access Control Modifications and Additional Physical Layer Specifications for 2-11 GHz", IEEE, Standard IEEE Std. 802.16a-2003, 2003.

7.Part 16: Air interface for fixed broadband wireless access systems. "Amendment for physical and medium access control layers for combined fixed and mobile operation in licensed bands," IEEE, Standard IEEE Std 802.16e/D12, October 2005.

8.A. E. Jones and T. A. Wilkinson "Block coding scheme for reduction of peak to mean envelope power ratio of multicarrier transmission schemes", IEE Elect. Lett, vol. 30, pp.2098 -2099, march 1994

9.X. Li and L. J. Cimini, "Effect of clipping and filtering on the performance of OFDM," Proc. IEEE VTC '97, pp. 1634-1638, 1997.

10.T. Wattanasuwakull, W. Benjapolakul, "PAPR Reduction for OFDM Transmission by using a method of Tone Reservation and Tone Injection" Fifth International Conference on Information, Communications and Signal Processing, ISBN: 0-7803-9283-3, pp. 273-277, 2005.

11.Malhar Chauhan, Prof.Abhishek Chobey, "PAPR Reduction in OFDM System Using Tone Reservation Technique", International Journal of Computer Technology and Electronics Engineering (IJCTEE), Volume 2, Issue 4, August 2012.

12.Malhar Chauhan, Prof.Abhishek Chobey, "PAPR Reduction in OFDM System Using Tone Reservation Technique", International Journal of Computer Technology and Electronics Engineering (IJCTEE), Volume 2, Issue 4, August 2012.

13.Sang Woo Kim, Heui Seop Byeon, Jin Kwan Kim, Heung-Gyoon Ryu, "An SLM Based Real Time PAPR Reduction Method Using Dummy Sequence Insertion in OFDM Communication", Fifth International conference on Information, Communication and Signal Processing, pp. 258-262, Dec 2005.

14.Luo, R.Z., Li, R., Wu, X.Q., Hu, S.N. and Niu, N. "A PTS Optimization Scheme with Superimposed Training for PAPR Reduction in OFDM System". Communications and Network, 6, 97-104, Feb 2014.

15.Abaurakhia S A, Badran E F and Darwish A E, "Linear Companding Transform for the Reduction of Peak-to-Average Power Ratio of OFDM Signals", IEEE Transactions on Broadcasting, Vol. 55, No.1, pp. 155 – 160, March 2009.
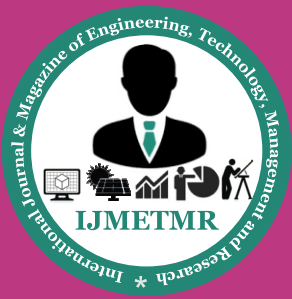
16.Eugen-Victor Cuteanu, Alexandru Isar, "PAPR Reduction of OFDM Signals using Active Constellation Extension and Tone Reservation Hybrid Scheme", The 8th Advanced International Conference on Telecommunications (AICT),pp. 156-163, 2012.

17.M. Niranjan, S. Srikanth, "Adaptive Active Constellation Extension for PAPR Reduction in OFDM Systems", International Conference on Recent Trends in Information Technology (ICRTIT),pp. 1186-1189, June 2011.

18.Madhuri. P, Dr. Malleshwari B L, "Peak to Average Power Ratio reduction by CB-ACE and Adaptive ACE algorithms", International Journal of Emerging Technology and Advanced Engineering, Vol.2, Feb 2012.

19.L. Wang and C. Tellambura, "An adaptive-scaling algorithm for OFDM PAR reduction using active constellation extension," in Proc. IEEE Vehicular Technology Conf., Sep. 2006, pp. 1–5.

20.Yuan Jiang. New companding transform for PAPR reduction in OFDM. IEEE Communications Letters. 2013; 14(4):282-284.

21.S. H. Han and J. H. Lee, "An overview of peak-to-average power ratio reduction techniques for multicarrier transmission", IEEE Wireless Communications, Vol. 12, pp. 55-65, April 2005.