A Brief Survey on Compressed Sensing for Clipping Noise Cancellation in DCO-OFDM Systems based on Interference Mitigation

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Abstract-Nowadays, OFDM is considered as potender for high speed networks. To enhance ghostly and optical power efficiencies with a direct circuit many-sided quality, a methodology is to exploit the otherworldly proficiency of DCO-OFDM and build up a fitting signal preparing to defeat the optical power effectiveness confinement caused by the clipping noise and the unreasonable DC inclination required in traditional DCO-OFDM systems.DC One-sided Optical OFDM are the most prominent. DCO-OFDM comprises in adding a DC inclination to the genuine bipolar DMT signal to change over it to a unipolar signal, bringing about a wasteful arrangement regarding optical power.

Keywords-Compressed Sensing, OFDM, Cliping Noise,Peak to average power ratio.

I. INTRODUCTION

OFDM is a widely used modulation technique to transmit digital data through wireless channels. Though it has many advantages, such as its robustness against intersymbol interference and fading, simplified channel equalization, and spectral efficiency, its primary drawback is high PAPR. Many techniques have been proposed to reduce the PAPR. Some examples are phase optimization, nonlinear companding transforms, Tone Reservation and Tone injection. One of the simplest approaches used for PAPR reduction is clipping. Clipping is applied on relatively few parts of the signal because the probability of high peaks is low.

Orthogonal frequency-division multiplexing is a kind of multicarrier modulation, where the data signal is transmitted over a number of narrowband subcarriers. The OFDM concept was first proposed in 1966, to maximize the data rate and minimize the interchannel and intersymbol interferences due to frequency-selective channels. OFDM has several advantages over single-carrier modulations including robustness against frequency-selective fading channels, simple effective equalization, efficient spectrum utilization, flexibility in subcarrier allocation, and adaptability in subcarrier modulation.

Despite their numerous advantages, namely their total immunity to inter symbol interferences, OFDM schemes suffer from a high peak to average power ratio. The main drawbacks of signals with high PAPR are the distortions due to the nonlinearity of nonlinear electric components such as power amplifiers, D/A and A/D converters.The bit error rate is a practical measure of probability of error, that permits to assess link quality. In an AWGN channel, the theoretical expression of the probability of error.

The block diagram of a very basic OFDM system is depicted in Fig. 1.1. The incoming data stream is first partitioned to blocks of N complex symbols. Each symbol is used to modulate one of the available subcarriers during a symbol period of T.

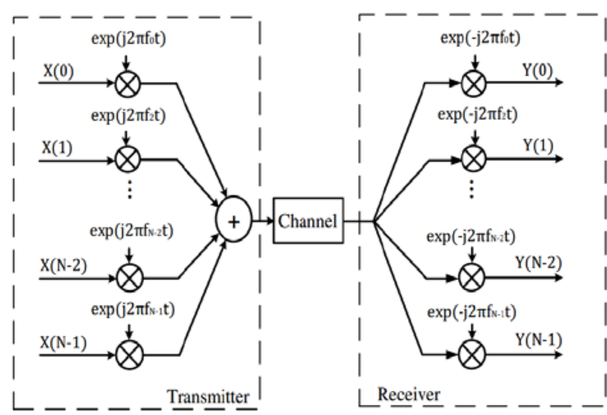

Fig. 1.1 The Block Diagram of a basic OFDM system.

It is known that clipping of the oversampled OFDM signals reduces the peak regrowth after D/A conversion. But, it causes out-of-band radiation which has to be filtered. Furthermore, clipping of OFDM signals causes clipping noise which has sparsity in time domain. There are several schemes to mitigate this clipping noise in each of the two sampling rate cases. The scheme in shows good clipping noise cancellation performance, but it requires iterative maximum likelihood (ML) estimation for all tones with clipping and filtering at the receiver, which causes lots of computation.

Compressed sensing (CS) is a sampling method that converts input signal in high dimension into the signal lying in the smaller dimension. In general, it is not enough to recover an unknown signal using compressed observations in the reduced dimension. where several tones are reserved at the transmitter before clipping and the receiver can reconstruct the clipping noise using CS reconstruction algorithm. However in this scheme, the reserved tones induce data rate loss and they should be demodulated at the receiver unlike the conventional tone reservation scheme. Additionally, this scheme shows poor bit error rate (BER) performance due to the small number of compressed observations and vulnerability of CS reconstruction algorithm against noise.

II. DCO-OFDM SYSTEM

DC biased optical OFDM is one of the simplest and earliest methods that generate unipolar OFDM schemes compatible with IM/DD systems. DC biased optical OFDM consists in adding a DC bias to the bipolar signal to convert it to an unipolar signal. The required DC bias to guarantee non-negativity is equal to the absolute value of the maximum negative amplitude of the bipolar OFDM signal. However, OFDM signals suffer from a high PAPR Comes in a high required bias level to ensure non-negative signals. In practice, for large values of N, the OFDM signal amplitude can be approximated by a Gaussian distribution. Therefore, in order to avoid an excessive DC bias and minimize the required optical power, an approach is to use a DC bias Kb proportional to the root-square of the electric power,

$$K_b = ha \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (2.1)$$

where k is the clipping factor and a2 is the variance of x(t) defined as,

$$a^2 = E\{x^2(t)\} \dots\dots\dots\dots\dots\dots\dots (2.2)$$

where (K_b) is the clipping noise component. The peak to average power ratio of OFDM signals increases with the number of subcarriers, thus increasing the DC bias required to minimize the clipping noise. On the other hand, the lower the added DC bias, the greater the number of subcarriers affected by the clipping process.

In DCO-OFDM, for N IFFT points, only E independent complex symbols are transmitted due to the Hermitian symmetry constraint. Moreover, the electric signal modulates the intensity (not the amplitude) of the optical transmitter. This implies that the required optical power is proportional to the OFDM signal amplitude.

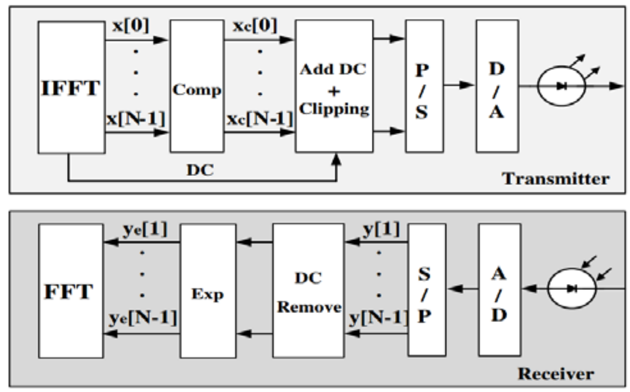

Fig. 2.1 The Block Diagram of Asymmetrically DCO-OFDM.

In conventional DCO-OFDM systems, the DC bias is directly added to the continuous signal at the DAC output and a hard clipping is performed to set to zero the remaining negative amplitudes. However, the dynamic range of the bipolar real ODFM signal increases with the spectral efficiency (i.e. the constellation size). Thus, if a moderate DC bias is used, more negative peaks are clipped, Comes in a significant clipping noise penalty (Fig. 2.1). As for large constellation sizes, the DCO-OFDM technique becomes inefficient in terms of bit error rate. To overcome this inefficiency, an approach is to increase the added DC bias, so that less negative peaks remain after DC bias addition, thus reducing the clipping noise penalty. However, this approach comes in an increase of the optical power required to transmit the unipolar signal, which impacts the optical power efficiency of DCO-OFDM systems.

III. LITERATURE SURVEY

Sr. No.	Title	Author	Year	Approach
1	Compressed sensing for clipping noise cancellation in DCO-OFDM systems based on observation interference mitigation	P. Miao, C. Qi, L. Wu, B. Zhu and K. Chen,	2017	In this paper, author propose a modified clipping noise cancellation scheme using compressed sensing (CS) technique with observation interference mitigation for direct current biased optical (DCO) orthogonal frequency division multiplexing (OFDM) systems.
2	Performance comparison of	H.	2017	authors compared the performance of the asymmetric

	visible light communication systems based on ACO-OFDM, DCO-OFDM and ADO-OFDM	Chen et al		and direct current bias limiting optical orthogonal frequency division multiplexing (ADO-OFDM), asymmetric limiting optical orthogonal frequency division multiplexing.
3	Near-Optimal Low-Complexity Sequence Detection for Clipped DCO-OFDM	J. Tan, Z. Wang, Q. Wang and L. Dai	2016	This letter proposes a maximum likelihood sequence detection (MLSD) method for the clipped DCO-OFDM, whereas the double-sided clipping characteristic is incorporated to improve the performance.
4	Clipping noise cancellation for OFDM systems based on priori aided compressed sensing	J. Gao, F. Yang and S. Liu	2016	This paper proposes a clipping noise cancellation scheme based on priori aided compressed sensing. Specifically, the clipping noise is reconstructed from the selected reliable observations in frequency domain based on the CS theory using greedy algorithms
5	Advanced A-law employing nonlinear distortion reduction in DCO-OFDM systems,	X. Zhang, P. Liu, J. Liu and S. Liu	2015	In this paper, an advanced A-law nonlinear companding algorithm is employed to reduce the nonlinear distortions from the light emitting diode (LED) on visible light communication (VLC) systems. The nonlinear transfer characteristics of LEDs are not identical.
6	Analysis of ACO-OFDM, DCO-OFDM and Flip-OFDM for IM/DD optical-wireless and optical-fiber system	R. Hassan and F. T. Z. Tuli	2015	The three types of orthogonal frequency division multiplexing techniques named Asymmetrically-clipped Optical OFDM (ACO-OFDM), DC biased Optical OFDM (DCO-OFDM) and Flip-OFDM systems are analyzed and compared in optical wireless and optical fiber system.
7	Reliable Data Aided Sparsity-Aware Approaches to Clipping Noise Estimation in OFDM Systems,	J. Lee and S. Lee,	2012	In this paper, authors propose reliable data aided sparsity-aware approaches to estimate and cancel the clipping noise in OFDM systems.

P. Miao, C. Qi, L. Wu, B. Zhu and K. Chen,[1] In this paper, authors propose a modified clipping noise cancellation scheme using compressed sensing (CS) technique with observation interference mitigation for direct current biased optical (DCO) orthogonal frequency division multiplexing (OFDM) systems. The interference components in potential observations are theoretically analyzed and approximately estimated by exploiting the statistical model of the clipped DCO-OFDM signal. Then, the modified CS scheme eliminates the estimated interference from the potential observations, which can minimize the contamination influence of channel noise on CS recovery algorithm. In addition, a strategy jointly considering the compressed ratio and the decision noise is presented to generate the measurement matrix, which can sample the reliable data tones as final observations. With this scheme, the clipping noise in time domain can be effectively corrected and the bit error rate (BER) performance of the system is significantly improved. Simulation results demonstrate that the proposed scheme can perform well even under severe clipping conditions.

H. Chen et al [2] authors compared the performance of the asymmetric and direct current bias limiting optical orthogonal frequency division multiplexing (ADO-OFDM), asymmetric limiting optical orthogonal frequency division multiplexing (ACO-OFDM), and the direct current bias limiting optical orthogonal frequency division multiplexing (DCO-OFDM) in visible light communication (VLC) systems. authors optimize the power ratio between ACO and DCO parts in ADO-OFDM. The results show that ADO-OFDM has better performance than DCO-OFDM at small bias value, which indicate higher power spectral efficiency. It is also shown that the BER of ACO-OFDM with 16-QAM format is smaller than that of ADO-OFDM with 4-QAM format.

J. Tan, Z. Wang, Q. Wang and L. Dai [3] The inherent high peak-to-average power ratio issue of dc-biased optical orthogonal frequency division multiplexing (DCO-OFDM) is sensitive to the limited dynamic region of light emitting diode component and prone to clipping distortion, which deteriorates the performance of visible light communication systems. This letter proposes a maximum likelihood sequence detection (MLSD) method for the clipped DCO-OFDM, whereas the double-sided clipping characteristic is incorporated to improve the performance. Besides that, a near-optimal low-complexity MLSD method is presented to reduce the calculation complexity. Simulations demonstrate that the proposed low-complexity MLSD receiver could approach the performance of ideal case of non-clipped DCO-OFDM.

J. Gao, F. Yang and S. Liu [4] Clipping noise, which could cause out-of-band radiation and increase bit error rate in orthogonal frequency division multiplexing systems, is necessary to mitigate. This paper proposes a clipping noise cancellation scheme based on priori aided compressed sensing. Specifically, the clipping noise is reconstructed from the selected reliable observations in frequency domain based on the CS theory using greedy algorithms. With the aid of a priori partial support obtained from the received time-domain signals, the proposed method improves the accuracy and robustness of the recovery. Simulation results show that the proposed scheme outperforms other conventional clipping noise cancellation counterparts.

X. Zhang, P. Liu, J. Liu and S. Liu [5] In this paper, an advanced A-law nonlinear companding algorithm is employed to reduce the nonlinear distortions from the light emitting diode (LED) on visible light communication (VLC) systems. The nonlinear transfer characteristics of LEDs are not identical. But the transfer effect of an LED can be modeled as a linear transfer range with the maximum and minimum forward voltages. Therefore, the signal will be truncated when the signal amplitude is larger than the maximum limit or smaller than the minimum limit. The advanced A-law companding algorithm can concentrate the signal amplitude to the limited linear transfer range and decrease the truncation distortion. authors evaluate the performance of the proposed advanced A-law companding algorithm comparing with typical A-law and uncompanded schemes via simulations in the direct current biased optical orthogonal frequency division multiplexing (DCO-OFDM) system. Experimental results demonstrate that the advanced A-law companding algorithm can effectively alleviate the nonlinear distortion of the DCO-OFDM system in terms of system bit error ratio (BER) performances.

J. Gao, F. Yang and S. Liu [6] The three types of orthogonal frequency division multiplexing techniques named Asymmetrically-clipped Optical OFDM (ACO-OFDM), DC biased Optical OFDM (DCO-OFDM) and Flip-OFDM systems are analyzed and compared in optical wireless and optical fiber system. Data are taken using MATLAB and the simulation software called Optisystem 13. The techniques are compared in terms of their bit error rate (BER) with respect to electrical energy to the noise power ratio (E_b/N_0) in presence of additive white Gaussian noise in case of optical wireless channel and by thermal noise in case of optical fiber channel. Different forms of Quadrature Amplitude modulation (QAM) have been used for modulating the OFDM signal such as 4-, 16-, 64 and 256-QAMs. After the final analysis, it is seen that ACO-OFDM requires a lower power to reach the target BER of 10^{-4} compared to DCO-OFDM and Flip-OFDM in both optical wireless and fiber channels. In the last part, the three bipolar OFDM systems are analyzed by observing their receiver sensitivity using PIN photodiode in 25 km optical fiber channel. The result shows that ACO-OFDM has a better sensitivity than DCO-OFDM and Flip-OFDM.

J. Lee and S. Lee, [7] In this paper, author propose reliable data aided sparsity-aware approaches to estimate and cancel the clipping noise in OFDM systems. Those are motivated by the fact that reliable data can be exploited to estimate the clipping noise in a successive interference cancellation (SIC) manner. When the clipping noise has relatively large support, a data non-aided method is not class enough to estimate the clipping noise well due to the compressed sensing (CS) based measurement shortages. Simulation results demonstrate the effectiveness of our proposed methods in estimating the clipping noise and approaching the performance with no clipping noise.

IV. PROBLEM IDENTIFICATION

The demand of high data rates and personal communication has driven research on the various techniques which can fulfill these demands along with minimum distortion in the signals. One of the possible solutions is OFDM transmission over optical channel i.e. radio over fiber transmission using multicarrier modulation. For multicarrier OFDM symbol, a proper control over multi-tones is required to best utilize the available bandwidth and to acquire more distortion less distance coverage. The demand of high data rates and personal communication has driven research on the various techniques which can fulfill these demands along with minimum distortion in the signals.

V. CONCLUSION

In this paper basic study of Compressed Sensing for Clipping Noise Cancellation in DCO-OFDM Systems. Our aim here is to develop a clipping recuperation algorithm that utilizations greatest data to upgrade the recuperation procedure, runs quicker than different CS conspires and takes after a straightforward Investigation of signal is then made positive by clipping the whole negative trip. Since just the positive part is transmitted, ACO-OFDM has more optical power effectiveness than DCO-OFDM. The purpose for the high PAPR is that the signal in the time space is the aggregate of numerous narrowband signals, bringing about high extents eventually examples . The high PAPR signal in distortions when the transmitted signal is subjected to a transmitter power amplifier.

REFERENCES

[1] P. Miao, C. Qi, L. Wu, B. Zhu and K. Chen, "Compressed sensing for clipping noise cancellation in DCO-OFDM systems based on observation interference mitigation," 2017 9th International Conference on Wireless Communications and Signal Processing (WCSP), Nanjing, 2017, pp. 1-6.

[2] H. Chen et al., "Performance comparison of visible light communication systems based on ACO-OFDM, DCO-OFDM and ADO-OFDM," 2017 16th International Conference on Optical Communications and Networks (ICOCN), Wuzhen, 2017, pp. 1-3.

[3] J. Tan, Z. Wang, Q. Wang and L. Dai, "Near-Optimal Low-Complexity Sequence Detection for Clipped DCO-OFDM," in IEEE Photonics Technology Letters, vol. 28, no. 3, pp. 233-236, 1 Feb.1, 2016.

[4] J. Gao, F. Yang and S. Liu, "Clipping noise cancellation for OFDM systems based on priori aided compressed sensing," 2016 IEEE International Symposium on Broadband Multimedia Systems and Broadcasting (BMSB), Nara, 2016, pp. 1-4.

[5] X. Zhang, P. Liu, J. Liu and S. Liu, "Advanced A-law employing nonlinear distortion reduction in DCO-OFDM systems," 2015 IEEE/CIC International Conference on Communications in China - Workshops (CIC/ICCC), Shenzhen, 2015, pp. 184-188.

[6] R. Hassan and F. T. Z. Tuli, "Notice of Violation of IEEE Publication Principles
Analysis of ACO-OFDM, DCO-OFDM and Flip-OFDM for IM/DD optical-wireless and optical-fiber system," 2015 IEEE International Conference on Telecommunications and Photonics (ICTP), Dhaka, 2015, pp. 1-5.

[7] J. Lee and S. Lee, "Reliable Data Aided Sparsity-Aware Approaches to Clipping Noise Estimation in OFDM Systems," 2012 IEEE Vehicular Technology Conference (VTC Fall), Quebec City, QC, 2012, pp. 1-5.

[8] E. B. Al-Safadi and T. Y. Al-Naffouri, “Peak reduction and clipping mitigation in OFDM by augmented compressive sensing,” IEEE Trans. Signal Process., vol. 60, no. 7, pp. 3834-3839, 2012.

[9] A. Gomaa and N. Al-Dhahir, “A sparsity-aware approach for NBI es-timation in MIMO-OFDM,” IEEE Trans. Wireless Commun, vol. 10, no. 6, pp. 1854-1862, 2011.

[10] T. Blumensath and M. E. Davies, “Normalized Iterative Hard Thresh-olding: Guaranteed Stability and Performance,” IEEE J. Sel. Topics Signal Process., vol.4, no.2, pp.298 -309, 2010.

[11] S. Ji, Y. Xue, and L. Carin, “Bayesian compresive sensing,” IEEE Trans. Signal Process, vol. 56, no. 6, pp. 2346-2356, 2008.

[12] J. A. Tropp and AC. Gilbert, “Signal Recovery From Random Measure-ments Via Orthogonal Matching Pursuit,” IEEE Trans. Inf. Theory, vol.53, no.12, pp.4655-4666, 2007.

[13] K. K. Herrity, A.C. Gilbert, J. A. Tropp, “Sparse Approximation Via Iterative Thresholding” Proc. IEEE Int. Conf. Acoust., Speech, Signal Process., vol.3, no., pp.III,III, 14-19, 2006.