Performance Analysis in ACO-OFDM based OWC Systems by Mitigating Clipping Noise

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ABSTRACT

OFDM transmission in optical wireless channel is established via asymmetrically clipped optical OFDM (ACO-OFDM). Clipping is one of the simplest methods to reduce the high peak to average power ratio (PAPR). Clipping leads to additional in-band distortion and out-of band distortion. In this paper it is proposed to mitigate the clipping noise by iterative reconstruction based method and Channel coding method. The out of band distortion is reduced by filtering and in-band distortion by inserting pilot samples. The clipped samples are reconstructed at the receiver and reduce the clipping noise in the presence of AWGN in channel.

General Terms- Optical Wireless Communication, Clipping noise suppression

Keywords- OFDM, Clipping noise suppression, iterative reconstruction method

1. INTRODUCTION

Optical wireless communication can be opted as an efficient medium for communication because of its virtually unlimited and unregulated bandwidth. In optical wireless communication it is possible to achieve a 1 to 10 Gbps data rate over a distance of 1 to 5 km for out-door application Orthogonal frequency division multiplexing is used widely in wireless communication systems since it provides an effective solution to inter-symbol interference (ISI) caused by a dispersive channel [3]. In OFDM high Peak to average power ratio and Inter-carrier interference occurs. High PAPR occur when signal is converted into time domain through IFFT the resulting signal is sum of n number of subcarrier and the peak of resulted signal becomes n times higher than normal averaged signal [8].

Several solutions have been proposed to reduce the PAPR of OFDM signals. Clipping is one of the simplest methods in reducing PAPR. Clipping is performed in the digital part of the transmitter. Digital clipping suffers from in-band distortion, out-of-band distortion, which reduces the spectral efficiency and peak regrowth after digital to analog conversion occurs [6]. Optical OFDM transmission has become a fast progressing and vibrant research field in optical fibre communications.

In optical OFDM method, the information is carried on the intensity of optical signal and therefore the signal should be unipolar (positive). Two forms of unipolar OFDM are asymmetrically-clipped OFDM (ACO-OFDM) and dc-biased optical OFDM (DCO-OFDM). In DCO-OFDM, a dc-bias is added to the signal. In ACO-OFDM the odd subcarriers are chosen for data transmission and setting the even ones to zero, the information can be successfully decoded from odd subcarriers at the receiver. ACO-OFDM requires lower optical power and data rate when compared to DCO-OFDM for a given BER. Clipping is an effective solution to PAPR by performing clipping on the Analog signal or on the up-sampling version of the digital signal [3]. When Clipping is performed in pilot aided OFDM system it will lead to increase in clipping noise over pilot symbols. Separate pilot symbol sequence & Data sequence are added and clipping is employed after IFFT. In reconstruction the clipping noise over pilot sequence can be removed by filtering. Though this method improves system performance, it results in high peak re-growth for various clipping ratio [7].

Decision Aided Reconstruction is an iterative reconstruction technique. As in this DAR, an estimate of clipped signal is obtained and decisions over clipped sequence are made on the transmitted samples in frequency domain. Clipped samples are detected and reconstruction is performed. The Decision/Detection error may occur i.e., missing a few clipped samples or falsely replace as unclipped samples**.** In least square based reconstruction method it requires formation of linear equation from information of zero padding in frequency domain and also requires extra bandwidth [9].

Clipping is carried out using Oversampling method to reduce high peak to average power ratio. Oversampling is performed by padding zeroes with the modulated bits. In reconstruction the average rate of samples of a signal is above nyquist rate, the lost samples can be recovered based on other samples. In the iterative reconstruction method an assumed statistical model of clipped distortion signal is constructed this approximated distortion signal is subtracted from received signal. The resulting signal is clipped and filtered, which can be used as an approximation for next iterative signal. The higher the iteration shows better results. To improve BER the channel coding method is also performed and the results are compared.

2. SYSTEM DESCRIPTION

The input bit stream is modulated at the transmitter using a chosen modulation scheme m-QAM, the complex bit stream is obtained. The OFDM system block diagram is shown in fig.1, with such that oversampling is performed with 3N zeros and taking 4N point FFT/IFFT. For the N size IFFT, the N subcarriers are used to form an OFDM frame. In ACO-OFDM, N/4 samples of complex bit stream is mapped with

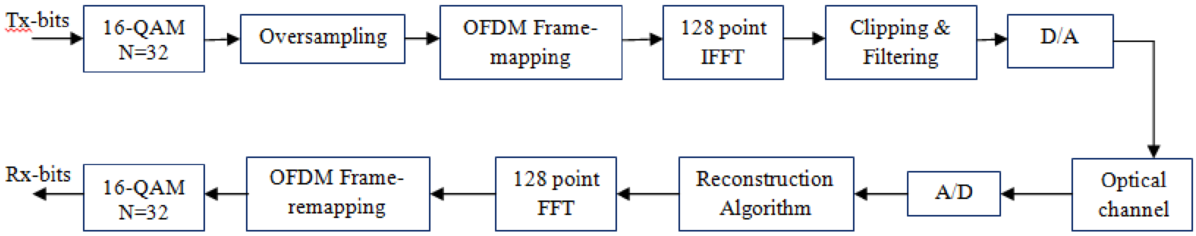

Fig 1. OFDM Transmitter /Receiver

the half of odd subcarriers whereas the even subcarriers are mapped to zero.

In ACO-OFDM the N/4 symbols in complex bit streams X(n) are mapped with the half of the odd subcarriers, then the frame mapping is $X_{frame}(b)$, b=1,3,5,.....N/2-1, where the even subcarriers are set to zero.

In order to reduce PAPR, Clipping is performed in the digital part of the signal and the clipping value is chosen such that higher the value then it is sensitive to loss of information. The clipping may leads to out-of band and in-band distortion. Out-of band distortion is reduced by filtering and in-band distortion is reduced by adding cyclic prefix. In general cyclic prefix is added in OFDM to overcome inter-symbol interference (ISI) and inter-carrier interference (ICI), where the CP will have a negligible impact on SNR and spectral efficiency in OWC [1]. The baseband signal received at the receiver is said to have baseband transmitted signal along with noise,

$$y(t) = c(t)x(t)+n(t) \qquad (1)$$

where x(t) represents transmitted signal, c(t) represents the distortion over the signal, n(t) represents the noise over the signal.

3. PROPOSED METHOD

In the iterative reconstruction based method, proposed method, the clipping distortion mitigation is performed by constructing an assumed statistical model of clipped distortion signal, this approximated distortion signal is subtracted from received signal. The resulting signal is clipped and filtered, which can be used as an approximation for next iterative signal. The higher the iteration shows better results.

The fig 2. is the block diagram of iteration method which describes the method of obtaining an approximation for the inverse of the distortion function. The approximated signal is distorted by distortion function, S.

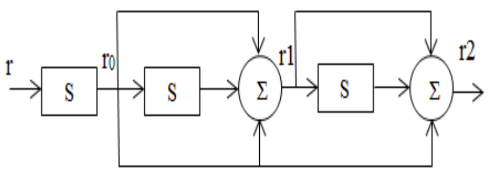

Fig 2. Iterative method

The iterative method can be expressed as,

$$R_n(t) = \lambda SR(t)+(I-\lambda S)R_{n-1}(t) \qquad (2)$$

Where S is the distortion factor, $R_n(t)$ is the output of nth iteration module, λ is the relaxation factor and the initial condition is $R_0(t)$ = S.R(t). If the power of the distortion signal is less than the power of the desired signal, the iterative method converges to the desired signal after a number of iterations.

The iterative method can be used for the clipping distortion cancellation in OFDM system. Distortion signal is the signal degradation by clipping and filtering to reduce PAPR, the iterative reconstruction method is used to find the inverse of this distortion at the receiver. When comparing to least square based reconstruction method this iterative reconstruction method does not require any additional bandwidth.

4. SIMULATION RESULT

In simulation the BER performance of Iterative reconstruction method is shown in which oversampling is performed at the rate of 3N and the clipping is performed with chosen minimum threshold of 2. Fig 3, shows the OFDM signal with odd subcarriers modulated. Fig 4, shows the BER performance of iterative reconstruction method with clipping threshold of 2, with increasing iteration value the performance improves.

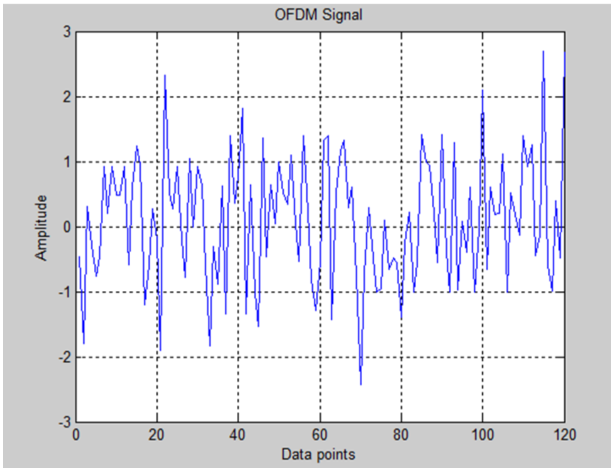

Fig 3. OFDM Signal

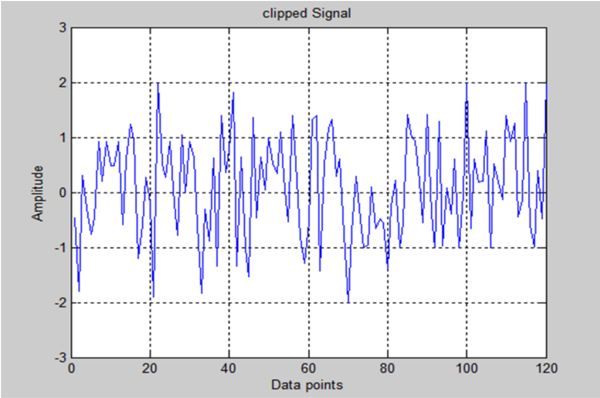

Fig 4. ACO-OFDM with clipping performed in minimum threshold of 2

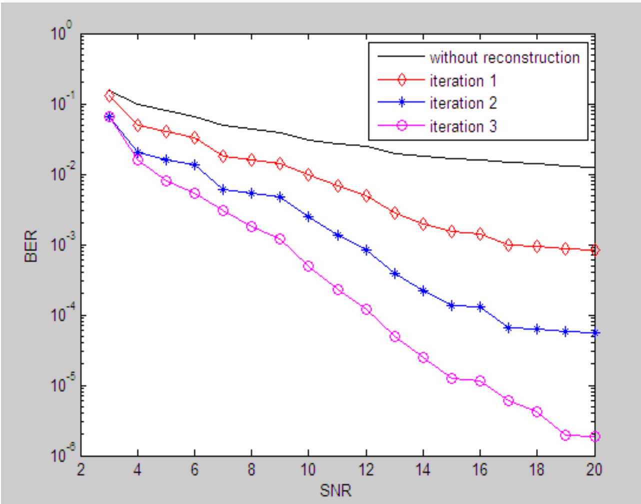

Fig 5. BER performance of iterative reconstruction method with clipping threshold of 2

6. CONCLUSION

To mitigate the clipping noise in OFDM an iterative reconstruction method is chosen and the method provides increasing bit error rate with increasing iterations. It does not require extra bandwidth and performs better in the presence of AWGN in the channel. In future work the channel encoding method is performed in OFDM signal, with Least square method for reconstruction and its bit error rate performance to be compared with the iterative reconstruction method.

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