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Asymmetrically Clipped Optical with Orthogonal Frequency Division Multiplexing Technique for Advance Wireless Communication System

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***Abstract*— The ever-increasing demand for high data rates, improved spectral efficiency, and robustness in wireless communication systems has fueled extensive research in advanced modulation and access techniques. Orthogonal Frequency Division Multiplexing (OFDM) has emerged as a promising candidate due to its ability to mitigate multipath fading and improve spectral efficiency. However, traditional OFDM systems face challenges in adapting to varying channel conditions and optimizing system performance. This paper presents an innovative Adaptive Technique based on Asymmetrically Clipped Optical (ACO-OFDM) for advanced wireless communication systems. The proposed technique combines the strengths of OFDM with the adaptability of ant colony optimization algorithms to address the dynamic nature of wireless channels effectively. By intelligently adjusting key OFDM parameters such as subcarrier spacing and modulation scheme, ACO-OFDM optimizes communication performance optimize improved results.**

IndexTerms —ACO-OFDM, ADO, Optical, Wireless.

I. Introduction

Asymmetric clipping of optical orthogonal frequency-division multiplexed (O-OFDM) channels [1, 2] can reduce the optical power requirement for a given data rate because no optical power is wasted in DC-biasing a bipolar OFDM waveform to become unipolar – negative values are simply set to zero. This zero-added-bias O-OFDM offers a greater electrical signal to noise ratio (SNR) for a given optical power [3] than simply adding a large DC-bias, as in DC-biased O-OFDM (DCO-OFDM), to avoid clipping of the negative-going peaks. A high SNR can support high-order quadrature amplitude modulation (QAM), increasing the attainable data rates in fiber and wireless light communications systems that have a limited modulation bandwidth of their electro-optic components. Alternatively coherent optical channels can provide high SNRs [4], including channels with a reference carrier [5]; however, non-coherent reception is simpler and less-bulky, and importantly has a lower cost for applications such as for visible lightwave communications [6] and short-reach fiber links.

Common forms of clipped OFDM signal include: asymmetrically clipped optical OFDM (ACO-OFDM), which uses spectral allocation of subcarriers to reduce or eliminate the effects of clipping (either a gap between the subcarrier band and DC [1], or by using only odd subcarriers [2]), and Flip-OFDM [7, 8], which transmits the positive, then negated negative, parts of the signal in two consecutive positive-valued blocks. ACO-OFDM and Flip/U-OFDM offer the same 'halved' spectral efficiencies, due to either the halving of the number of available subcarriers (ACO-OFDM) or the doubling of the required time to transmit an OFDM symbol (Flip/U-OFDM). However, at the receiver, Flip/U-OFDM de-maps multiple frequencies in the transmitted channel into each optical subcarrier, so it is difficult to equalize the channel's imperfections in the frequency domain. Due to half the transmitted samples being zero-valued, techniques are available to reduce noise in Flip/U-OFDM, using information in the clipped portion of the waveform [7]. Similar techniques exist for ACO-OFDM [10–13]. Flip/U-OFDM systems offer advantages in the size of the Fourier transform, which can be halved compared with ACO OFDM. In both systems, the halving of spectral efficiency is particularly problematic if a high data rate is required through a low-bandwidth channel, such as when using light-emitting diodes or directly-modulated lasers in wireless and short-haul optical links, respectively. The halving of the spectral efficiency in both ACO-OFDM and Flip/U-OFDM has the consequence that the bandwidths of the electrical and optoelectronic components must be doubled, for a given modulation format, as must the sampling rates of the digital to analog and analog converters, which is costly and may make these techniques unattractive [4].

To improve spectral efficiency, it is possible to superimpose a DCO-OFDM channel upon an ACO-OFDM channel, using the odd-frequency subcarriers for ACO-OFDM and the even-frequency subcarriers for DCO-OFDM—called asymmetrically clipped DC-biased optical OFDM (ADO-OFDM) [5]. .

II. Literature Survey

J. Li et al.,[1] proposed receiver is less sensitive to the clipping distortion. As the nonlinearity increased, the proposed scheme can outperform the conventional iterative solution in nonlinearity channel for LACO-OFDM in visible light communications.

X. Liu et al.,[2] present the iterative pairwise ML detection, the ACO-OFDM symbols are detected in frequency domain and the SNR gain of 3 dB could be available. Simulation results show that the pairwise ML receiver without iteration provides the SNR improvement of 1.5~2.7 dB for 7% forward error correction (FEC) limit. The proposed iterative receiver gives a SNR gain of 2.6~2.9 dB with 7% FEC limit.

R. Jiang et al.,[3] propose a low-complexity iterative algorithm to obtain an optimal solution. Simulation results verify that the proposed algorithm converges quickly, and the uplink ACO-OFDM-NOMA system using the proposed algorithm has better utility compared to the uplink ACO-OFDM-NOMA system using the greedy algorithm and the traditional uplink ACO-OFDM access (ACO-OFDMA) system.

Y. Jiang et al.,[4] propose a superposition based light emitting diode (LED) nonlinearity mitigation scheme for asymmetrically clipped optical-orthogonal frequency division multiplexing (ACO-OFDM) optical wireless communications (OWC) systems, where a non-redundant signal stream is superimposed with an ACO-OFDM source signal stream, requiring no pilot and no side information.

R. Bai et al.,[5] optical power allocation schemes over the layers of ALACO-OFDM are developed with the objective of optimizing uncoded transmission performance and the achievable information rate respectively. Additionally, a theoretical bound on the uncoded BER of ALACO-OFDM is derived.

X. Zhang et al.,[6] provided for quantifying the capacity improvement attained by the proposed algorithm. Moreover, an adaptive scheme is proposed for adjusting the number of layers to be used for maximizing the capacity at different SNRs.

X. Liu et al.,[7] the single-FFT receiver, the different layers of ACO-OFDM signals are distinguished in time domain without the FFT/IFFT pair.

Because only one FFT is employed in the proposed receiver, the complexity of O(Nlog2N) can be achieved, which is much lower than the complexity of the conventional LACO-OFDM receiver.

T. Zhang et al.,[8]a triple-layer hybrid optical orthogonal frequency division multiplexing (THO-OFDM) for intensity modulation with direct detection (IM/DD) systems with a high spectral efficiency is proposed. We combine N -point asymmetrically clipped optical orthogonal frequency division multiplexing (ACO-OFDM), N /2-point ACO-OFDM, and N /2-point pulse amplitude modulated discrete multitoned (PAM-DMT) in a single frame for simultaneous transmission.

T. Q. Wang et al.,[9] the clipping noise caused by the DDC mainly falls onto the first layer, and its impact is gradually reduced in the subsequent layers. In order to combat the clipping noise, a novel receiver based on decision aided reconstruction is proposed. Simulation results show that the proposed receiver can effectively mitigate the clipping noise, leading to significant improvement of bit error rates over the conventional receiver.

Y. Sun et al.,[10] the energy efficiency and the spectral efficiency for orthogonal frequency division multiplexing (OFDM)-based visible light communication schemes are studied, which is crucial for practical application with limited energy resources.

A. W. Azim et al.,[11] layered discrete Hartley transform (DHT)-spread asymmetrically clipped optical-orthogonal frequency division multiplexing (LDHTS-ACO-OFDM) is presented; it uses DHT for multiplexing/demultiplexing and pulse-amplitude modulation (PAM) alphabets.

A. James Lowery et al.,[12] interleaved discrete-Fourier-transform-spread L/e-ACO (IDFTS-L/e-ACO) is proposed for the IM/DD OWC. Specifically, two kinds of IDFTS-L/e-ACO techniques are proposed. For readability, one is denoted as HS-IDFTS that implements Hermitian symmetry (HS) to generate real-valued signals, and the other is denoted as RI-IDFTS that employs the real and imaginary separation (RIS) to transform complex signals to real-valued ones.

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III. METHODOLOGY

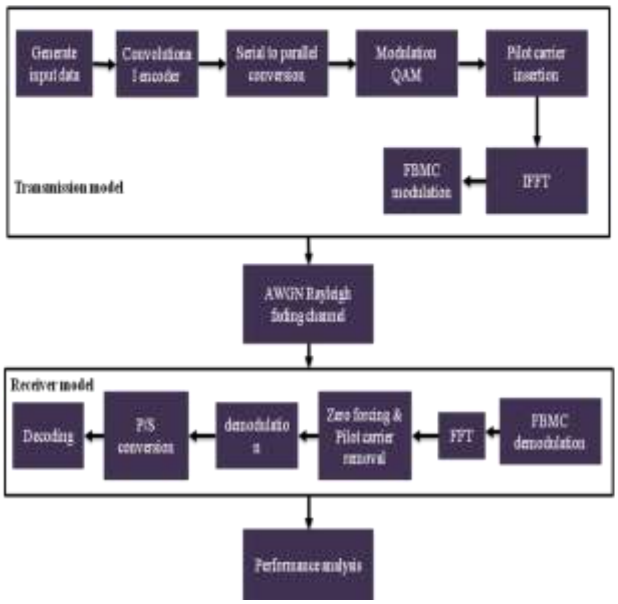

Figure 1: Flow chart

The methodology is based on the following sub-modules-

- Transmission model
- Modulation
- Receiver model
- Performance analysis

Transmission Model

- OFDM Transmitter: Initially input signal is generated randomly. By using the conventional encoder can convert the input signal into binary stream.
- Adaptive modulation scheme is used for modulating the input signal, for which 16-QAM, 64-QAM modulation schemes used.

Modulation

- Quadrature amplitude modulation (QAM) is both an analog and a digital modulation scheme. It conveys two analog message signals, or two digital bit streams, by changing (modulating) the amplitudes of two carrier waves, using the amplitude-shift keying (ASK) digital modulation scheme or amplitude modulation (AM) analog modulation scheme.

Receiver Model:

- Reversal operations of OFDM transmitter process are performed. Removal of guard and cyclic prefix is performed and transformed the resultant signal by Fourier transform. Implemented demodulation scheme by using adaptive demodulator and decoding process performed for the demodulated signal and calculate the BER in the system.

Performance Analysis:

Finally the output signal is estimated over every channel and analyses the performance of SNR, BER and outage probability.

Performance of PAPR reduction schemes can be evaluated in the following three aspects:

(a) In-band ripple and out-of-band radiation that can be observed via the power spectral density
(b) Distribution of the crest factor (CF) or PAPR, which is given by the corresponding CCDF
(c) Coded and uncoded BER performance.

WORKING

The basic principle of OFDM is to divide the available bandwidth into a number of subcarriers, each of which carries a narrowband signal.

In ACO-OFDM, the high power portions of the signal are clipped asymmetrically before transmission. Specifically, the positive peaks of the signal are clipped more than the negative peaks, which reduce the PAPR of the transmitted signal. This is done by applying a non-linear transformation to the signal before it is transmitted.

At the receiver end, the signal is demodulated and the clipped portions of the signal are removed. This is done using digital signal processing techniques that can identify and remove the clipped portions of the signal. Once the clipped portions have been removed, the signal can be processed and decoded as in a traditional OFDM system.

The principle of ACO-OFDM can be summarized as follows:

1. *Asymmetric Clipping:* ACO-OFDM uses asymmetric clipping to reduce the peak-to-average power ratio (PAPR) of the OFDM signal. In ACO-OFDM, the positive and negative peaks of the OFDM signal are clipped by different levels, resulting in a reduced PAPR.

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2. *OFDM Modulation:* The clipped signal is then modulated onto an optical carrier using OFDM modulation. OFDM is a well-known modulation technique that divides the signal into multiple subcarriers, each of which is modulated with a lower data rate. This results in a more bandwidth-efficient transmission, as the available bandwidth is used more effectively.
3. *Optical Transmission:* The modulated signal is then transmitted over an optical fiber. Due to the reduced PAPR, the signal is less susceptible to nonlinearity effects, such as distortion and inter-symbol interference, which can occur when transmitting high-power signals over optical fibers.
4. *Signal Reception:* At the receiver, the signal is demodulated and the clipped peaks are reconstructed using a non-linear amplifier. The reconstructed peaks are then added back to the original signal to recover the transmitted data.

IV. Simulation And Results

The proposed work is simulated using the MATLAB software.

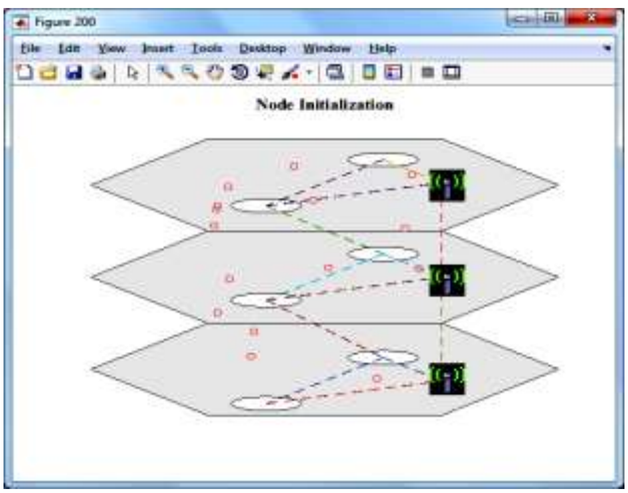

Figure 2: Simulation scenario

Figure 2 presents the simulation scenario which is use to define a set of assumptions for the simulation, such as the initial value of the node for communication.

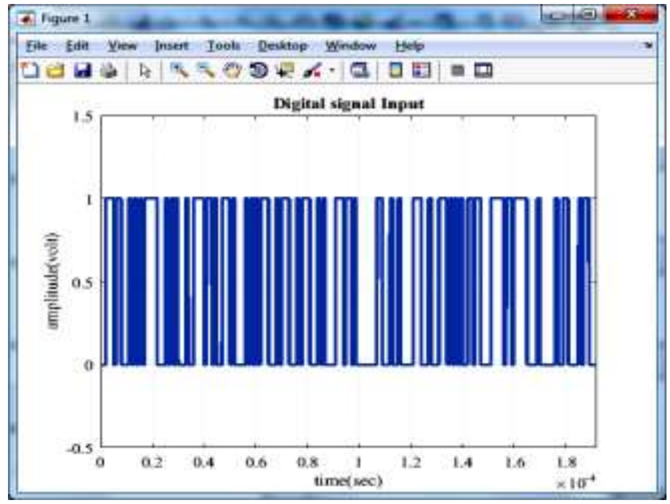

Figure 3: Digital signal input

Figure 3 presents digital signal input; it is a type of signal that represents data as a sequence of discrete values. In other words, it is a signal that uses a finite set of values to represent information.

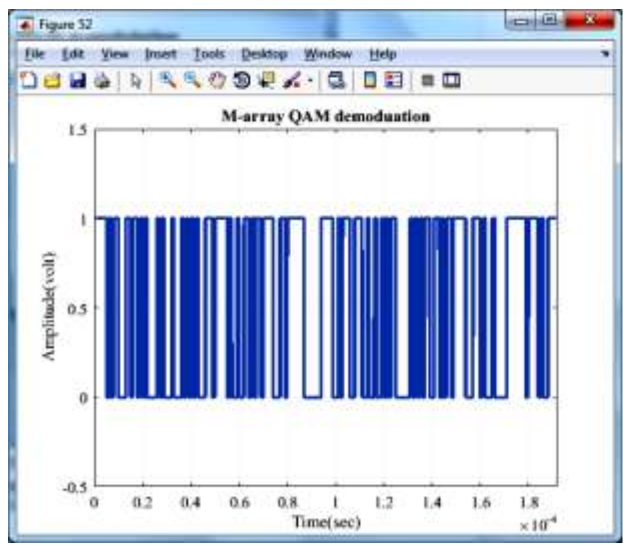

Figure 4: M-array QAM demodulation

Figure 4 presents demodulation, the complex symbols are then mapped back to their original binary values using a symbol demapping table. The demapping process depends on the modulation scheme used and the number of bits represented by each symbol.

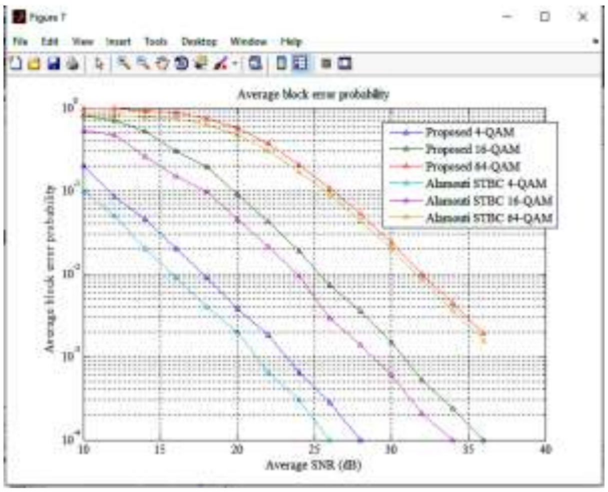

Figure 5: Average block error probability

Figure 5: presents the average block error probability. The average block error probability (ABEP) is a measure of the error rate of the system. It represents the probability that a block of data (i.e., a group of symbols or bits) is incorrectly decoded by the receiver.

Table 1:
Result Comparison

Sr No.	Parameters	Previous Work [1]	Proposed Work
1	SNR at 4-QAM	19 dB	28 dB
2	SNR at 16-QAM	26 dB	36 dB
3	SNR at 64-QAM	30 dB	37 dB
4	Min BER	10^{-4}	10^{-5}
5	Modulation order	4, 16, 64	4, 16, 64

Table 1 presents the simulation results comparison of the previous and the proposed work. The maximum value of the signal to noise ratio is achieved is 37dB in the proposed work while 30dB achieved by the previous work at 64-QAM. The minimum bit error ratio is 10-5 by the proposed while previous achieved is 10-4. Therefore the proposed work is significant better than the previous work.

V. Conclusion

This paper presents the Asymmetrically Clipped Optical Orthogonal Frequency-Division Multiplexing (ACO-OFDM) System for efficient wireless communication. Simulation is performed using MATLAB software. Simulated results shows that the maximum value of the signal to noise ratio is achieved is 37dB in the proposed work while 30dB achieved by the previous work at 64-QAM.

The minimum bit error ratio is 10-5 by the proposed while previous achieved is 10-4. Therefore the proposed work is significant better than the previous work.

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