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Verbose Receiver for Flip-OFDM in Optical Wireless Communication System

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Abstract

With the rapidly growing demand for data in wireless communications and the significant increase of the number of users, the radio frequency (RF) spectrum become one of the scarcest resources in the world. Motivated by the more and more crowed RF spectrum, optical wireless communications (OWC) has been identified as a promising candidate to complement conventional RF communication, especially for indoor short and medium range data transmission. In the proposed method flip OFDM is used to guarantee nonnegative signals in optical wireless communication (OWC) systems and flipped orthogonal frequency division multiplexing (FlipOFDM) transmits the positive and negative parts of the signal over two consecutive OFDM sub frames. An iterative receiver is then proposed to improve the transmission performance of Flip-OFDM by exploiting the signals in both sub frames. Simulation results show that the proposed iterative receiver provides significant signal to noise ratio (SNR) gain over the conventional receiver. Moreover, the iterative receiver also outperforms the existing advanced receiver.

Keywords: ***Flip OFDM, Iterative receiver, Optical wireless communications.***

INTRODUCTION

With the widespread organization of light deployment diodes (LEDs), optical wireless communication (OWC) has pulled an increasing interest in educated community and industry recently [1]. Because of its distinct advantages such as rich spectrum resources and high security purpose, OWC has replaces attractive alternate to radio frequency (RF) systems [2]. To accomplish high symbol rates and mitigate inter-symbol interference (ISI), orthogonal frequency division multiplexing (OFDM) has been utilized in OWC [3] – [5]. Since intensity modulation and direct detection (IM/DD) is continuously utilized as a part of OWC frameworks, the transmitted signals must be real and nonnegative. To resolve the issue of bipolarity in OFDM signals, a few OFDM methods have been proposed for OWC. They are direct current (DC) optical OFDM (DCO-OFDM) [6], asymmetrically clipped optical OFDM (ACO-OFDM) [7], along with pulse-amplitude-modulated discrete multi tone (PAM-DMT) [8].

DCO-OFDM adds a DC level to the OFDM symbols; this increases the power dissipation of the signal significantly. ACO-OFDM and PAM-DMT have no need of DC bias due to clipping operation, yet each has only half the spectral efficiency of DCO-OFDM. The authors in [9] introduced a novel OFDM procedure named as Flip-OFDM in which positive and negative parts of the signals are separately transmitted two consecutive OFDM subframes. In [10], authors demonstrated that Flip-OFDM can be modified to approach the spectral efficiency of DCO-OFDM with no biasing, it contributes to the practical applications of Flip-OFDM in OWC.

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In the conventional receiver for Flip-OFDM, the information is recovered by subtracting the negative signal frame from the positive signal frame [9]. This procedure is basic and straightforward. In any case, it expands the noise variance of the receiver symbols, making the performance much worse than that of bipolar OFDM with the same modulation scheme. To enhance the performance of Flip-OFDM, a time-domain noise filtering technique was introduced in [11] and investigated in [12]. Of course, the algorithm does not make full utilization of the signal structures. Here in this letter, an iterative receiver is proposed for Flip- OFDM by completely exploiting the structures of the received signals. Simulations confirm that the proposed iterative receiver is superior to different receivers.

ORTHOGONALITY OF OFDM

In communication model of the orthogonal frequency division multiplexing (OFDM), used sub carriers are orthogonal to each other. The Orthogonality helpful in preventing the overlapping between the sub carriers in the respective nature of frequency domain. The accuracy of communication model is simply based on how effectively utilizes the bandwidth and this is technically named as spectral efficiency or bandwidth efficiency, the utilized bandwidth efficiency is free of Inter carrier interference and also the absence of Inter carrier interference (ICI) is mainly due to usage of Orthogonality in orthogonal frequency division multiplexing.

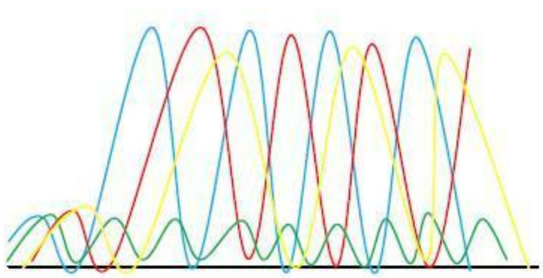

Fig.1. Orthogonality in orthogonal frequency division multiplexing (OFDM)

FLIP-OFDM SYSTEM

The Flip-OFDM block diagram is shown in figure 2. The input random signal symbol rate streams (high) are converted into symbol rate streams (low).

The important thing in the OFDM block diagram is the modulation scheme which modulates the low symbol rate streams in parallel way and this parallel stream given input to the IFFT block which transforms the frequency domain to time domain before it reaches the channel. Adding the cyclic prefix acts as the guard band and the reverse of transmission is accomplished at the receiver end.

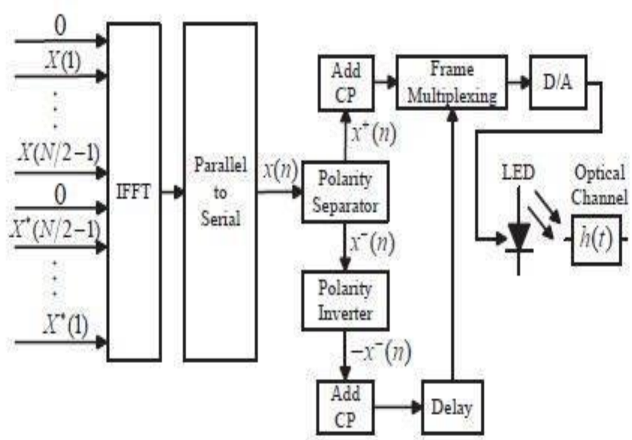

Fig.2. Block diagram of Flip-OFDM Transmitter

PROPOSED RECEIVER

The conventional receiver is basic and straightforward, but it doesn't fully exploit the structures of the received signals. Now in this paper we are performed iterations. If the number of iterations increases then bit error rate going to be decreases.

So in our proposed receiver we don't take the positive and negative parts of the signals directly, we have to make some modifications as shown below and establishing the relationship between the two received signals Y^+ , Y^- and the input data X.

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In this receiver let us consider |x| can be denoted as

$$|x| = S(X)\,x = S(X)\,W_N^{H}X,$$

Where S(X) is expressed as

$$S(X) = \text{diag}\{\text{sign}(x)\} = \text{diag}\{\text{sign}(W_N^{H}X)\}$$

From this the positive and negative parts of the signal can be written as follows,

$$x^{+} = \frac{x+|x|}{2} = \frac{x+S(X)W_N{}^{H}X}{2}$$

$$x^{-} = \frac{x-|x|}{2} = \frac{x-S(X)W_N{}^{H}X}{2}$$

From this the relationship between the Y+ and X can be derived as

$$Y^{+} = \frac{H + HW_N S(X) W_N{}^{H}}{2}X + Z^{+}$$

So finally the iterative receiver becomes

$$X^{i}{}_{LOS} = dec[Y^{+} - Y^{-}], i = 0$$

$$X^{i}{}_{LOS} = \text{dec}\{\tfrac{1}{2}[I + W_N S(X_{LOS}{}^{(i-1)}) W_N{}^{H}]Y^{+} + \tfrac{1}{2}[W_N S(X_{LOS}{}^{(i-1)}) W_N{}^{H} - I]Y^{-}\}, i = 1,2,\ldots\ldots,k$$

SIMULATION RESULTS

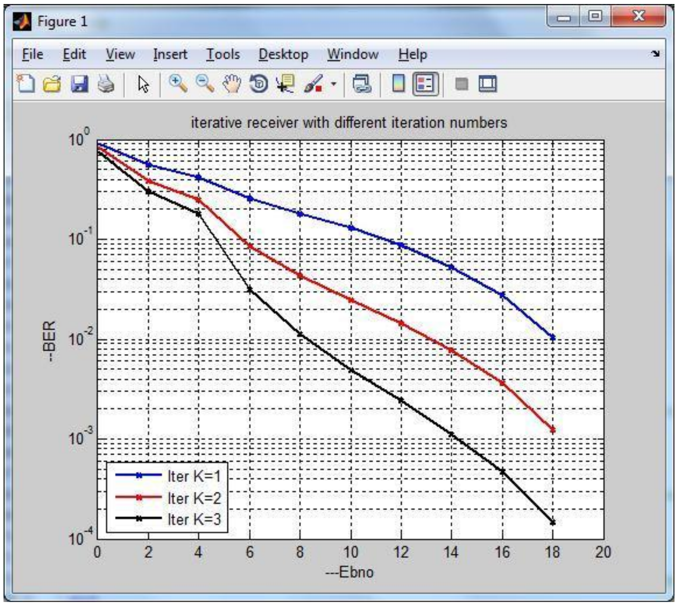

Figure3: Iterative receiver with number of iterations

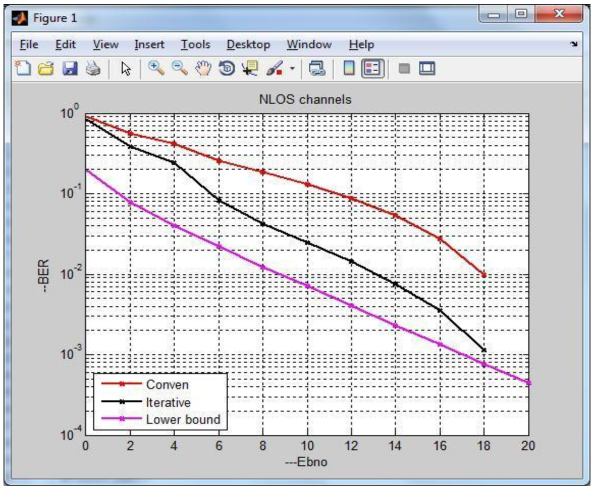

Figure4: NLOS channel in terms of BER

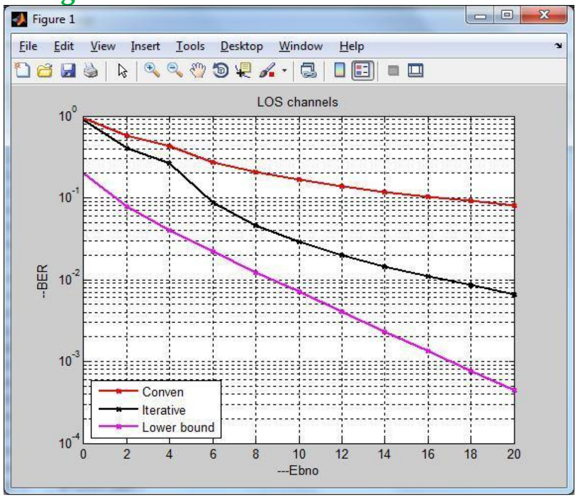

Figure5: LOS channel in terms of BER

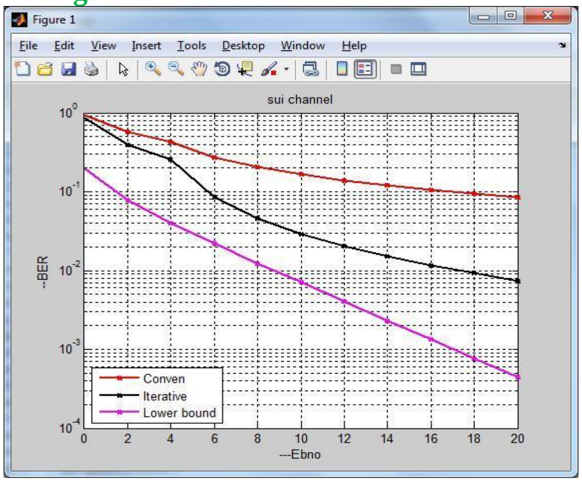

Figure6: SUI channel in terms of BER

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SNR	BER(LOS)	SUI Channel(LOS)
0	0.8945	0.8615
2	0.2225	0.2188
4	0.0988	0.0946
6	0.0550	0.0544
8	0.0352	0.0346
10	0.0231	0.0242
12	0.0174	0.0178
14	0.0129	0.0136

Table: Compare the BER results with last 2 figures

CONCLUSION

An iterative receiver is proposed for Flip OFDM in IM/DD based OWC systems. In order to improve the receiver performance, the iterative receiver obtains the additional diversity gain by exploiting the signals in both the positive sub frame and negative sub frame. The simulation results show that the iterative receiver with only two iterations provides a significant SNR gain over the conventional receiver. Moreover, the receiver is also superior to the existing advanced receiver.

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