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Hybrid OFDM/OOK Modulations in OCDMA Scheme for Free Space Optics

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Abstract

The study proposes hybrid analog/digital transmission format scheme which integrated optical code-division multiple-access (OCDMA) and polarization multiplexing technique in free space optics (FSO) transmission. Orthogonal frequency division multiplexing (OFDM) transmits as the analog format and (on-off keying) OOK transmits as digital format in the study, respectively. In the proposed hybrid OCDMA system, it has high-speed transmission, signal security and low cost…etc. The multiple access interference (MAI) can be efficiently eliminated by using the balanced detection scheme at the receive end.

Keywords: Optical Code-Division Multiple-Access (OCDMA), Free Space Optics (FSO), Orthogonal Frequency Division Multiplexing (OFDM), Multiple Access Interference (MAI)

1. Introduction

In recent years, peoples become closer and closer relationship between the networks. Because of hybrid coaxial cable transmission network change into a fiber optical transmission network, making people have a better internet experience. In the current study, we use the method of different states of polarizations to transmit analog/digital signals and then into optical code-division multiple-access (OCDMA) networks. Due to polarization modulator without using electronic circuit or impressed voltage to control, and has the same intensity of light signals in the outputs, which can mitigate fiber nonlinear effects and making the overall structure greatly improve the reliability of the transmission side.

At present, wired transmission interface is using fiber or coaxial cable to transmit signal. But in some place because of terrain effect (e.g., cliffs desert, both ends of the bridge). Wireless transmission system is one of the solutions to solve topographical constraints, but it is always disturbed by channel interference and shelter, severely reducing its effectiveness. We take advantage of the free space optics (FSO) approach as the way for last mile transmissions [1].

In this paper, we present optical spectral amplitude coding OCDMA (SAC-OCDMA) combining with polarization multiplexing to transmit analog signal of orthogonal frequency division multiplexing (OFDM) and digital signal of on-off keying (OOK) signals at the same time. In the past year, SAC-OCDMA system is attracted more attention because of the multiple access interference (MAI) elimination and preserve the orthogonality among the users in the system [2]. OFDM technique has been widely adopted in broadband wired and wireless communication systems, because it is robustness to the inter-symbol interference (ISI) and multi-path fading by a dispersive channel [3].

2. System Structure Description

Fig. 1 and 2 illustrate the structure of the proposed base stations (transmitters) and control station (receivers). This OCDMA multiplexing structure can transmit analog signal and digital signal at the same time and still preserve the ability of MAI elimination. We transmit OFDM signal as analog signal and OOK signal as digital signal. In this hybrid system, each base station needs a spectral encoder and a decoder in the receiver. The DFB laser array source is connected a $1\times(N-1)$ splitter which providing light source to each base station, shown in Fig. 1. The DBF laser source performs as optical carri-

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ers pass through a polarizer a polarization controller (PC), and a polarization beam splitter (PBS). The PBS allocates the orthogonal horizontal and vertical states of polarizations (SOPs) upper and lower arms, respectively.

Between base station and control station, FSO is used to be this structure channel. The control station received a composite signal comprising the transmitted chips of all the active base station. As shown Fig. 2, the received signal in the control station is divided in to $(N-1)$ -th parts by using the $1\times(N-1)$ splitter, and passed into each receiver. The signal was produced vertical and horizontal polarization states by using PBS. Two SOPs of vertical and horizontal output from the PBS which are split into an upper branch and the lower branch. The two different signals of vertical and horizontal passed balance detector, which computed the correlation difference between the two spectra and eliminate the interference of base station with un-matching codeword individually. The upper branch uses OFDM demodulator to revert analog original signal and lower branch uses digital OOK demodulator to revert digital OOK signal.

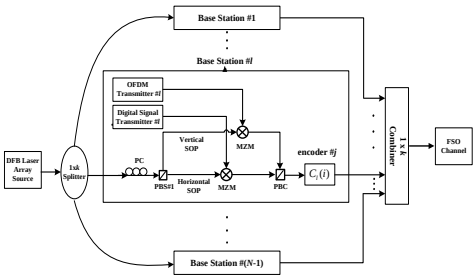


Fig. 1 The transmitter of proposing system

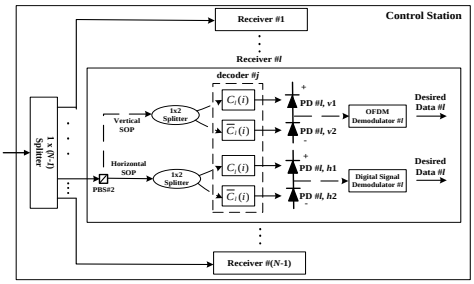


Fig. 2 The receiver of proposing system

Before analysis of the proposed system [4], the OFDM signal of the k-th base station is $O_{k,RF}(t)$:

$$O_{k,RF}(t) = A_{k,RF} \cdot \cos(2\pi f_{k,RF} t) \qquad (1)$$

where $A_{k,RF}$ is the amplitude of OFDM signal, and $f_{k,RF}$ is the carrier frequency.

And the analog OFDM signal is modulated by a multi-wavelength DFB laser as optical carriers and then pass through AWG encoder is:

$$O_k(t) = \sum_{i=1}^{N_c} P_s\left[1+\alpha \cdot O_{k,RF}(t)\right] \cdot C_k(i) rect(i) \qquad (2)$$

where $C_k(i)$ denote the i-th element of the k-th WHC codeword, α is the modulation index, P_s is the transmitted optical power, and $rect(i)$ function is given by:

$$\begin{aligned} rect(i) = u\left[v - v_0 - \frac{\Delta v}{2N_c}\left(-N_c + 2i - 2\right)\right] \\ - u\left[v - v_0 - \frac{\Delta v}{2N_c}\left(-N_c + 2i\right)\right] \end{aligned} \qquad (3)$$

At the receiver end, the instantaneous power spectral density (PSD) of the vertical and horizontal SOP's received optical signals can be expressed by the following:

$$\begin{aligned} r_v(v,t) = \frac{P_{sr}}{2\Delta v} \sum_{k=1}^{K} \sum_{i=1}^{N_c} P_s\left[1+\alpha \cdot Q_{O,RF}(t)\right] \\ \cdot C_k(i) rect(i) \end{aligned} \qquad (4)$$

$$r_h(v) = \frac{P_{sr}}{2\Delta v} \sum_{k=1}^{K} b_k \sum_{i=1}^{Nc} C_k(i) rect(i) \qquad (5)$$

where P_{sr} is the received effective power at the input port of each receiver, Δv is the light source bandwidth, K is the number of base station.

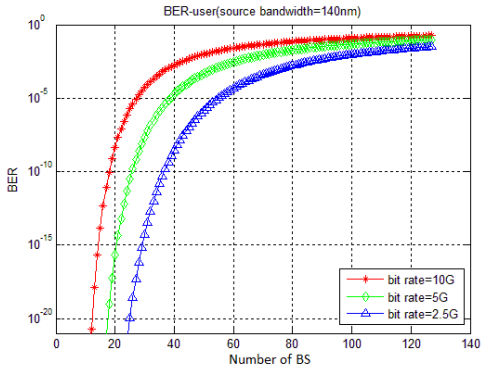
The relationship between bit-error-rate (BER) can employ as:

$$BER = \frac{1}{2} erfc\left(\sqrt{SNR/8}\right) \qquad (6)$$

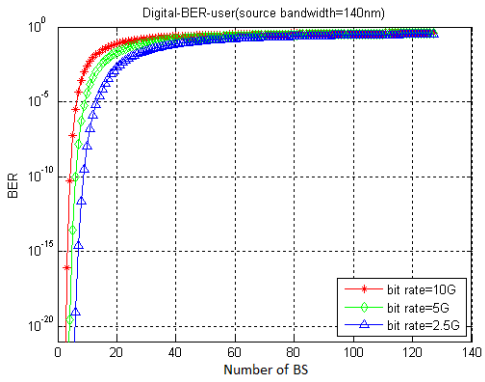
3. Performance Analysis and Discussion

FSO performance by several parameters for reference including geometric loss, link margin, the received power and bit error rate. In this paper, it considers the received power and bit error rate [5]. Fig. 3(a) and 3(b) illustrates the bit error rate (BER) relative to active users in dif-

ferent bit rate at the analog/digital signals, respectively. It had more active user when it had low bit rate.



(a) analog signal



(b) digital signal

Fig. 3 Illustrates the bit error rate (BER) relative to active users in different bit rate

4. Conclusions

In this study, we present hybrid analog/digital spectral OCDMA system. This system transmits two different kinds of format signal which contain analog and digital signals by using polarization multiplexing technique. The proposed hybrid system can transmit analog and digital signals at the same time such as digital TV and mobile phone system simultaneously. FSO is the main transmission channel in the study, which has the advantages of low cost, easy construction and terrain without restrictions … etc. The simulation results show that both OFDM signal as analog signal and OOK modulation as digital signal in the proposed hybrid OCDMA system perform good performance in FSO transmission.

Acknowledgement

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