A RoF-FSO communication system using 10Gbit/s polsk 4-PAM downstream signals

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Abstract. In this paper, the performance of a 60 GHz radio over fiber free space optics (RoF-FSO) communication system with 10Gbit/s 4-ary pulse amplitude modulation (4-PAM) polarization shift-keying (Polsk) downlink signal is proposed and designed. In the receiver, the 60GHz millimeter-wave with 4-PAM downstream signals is generated by the beating of two continuous light waves, and the high frequency signal is demodulated by self-mixing zero difference detection method. Meanwhile, the optical spectra, radio frequency (RF) spectrum, eye-diagram are measured, and the transmission performance of the used RoF-FSO system are analyzed.

1 Introduction

Recently, free space optical (FSO) communication, as a secure and high transmission rate communication technology, has attracted extensive attention in the broadband access network. The advantages of FSO are easy and fast deployment and portability, license-free operation, high transmission security etc [1-2]. However, optical signals transmission in free space are seriously influence by atmospheric turbulence [3-4]. Radio over fiber (RoF) technology is introduced to reduce the transmission loss and decrease the influence of electromagnetic interference on the system. RoF is a potential technology in wireless communication [5], which can solve problems such as the transmission loss of high-frequency wireless broadband signals and the limited bandwidth of electronic equipment. PAM is a modulation technique in which the amplitude of the carrier changes as the baseband signal changes. Moreover, atmospheric turbulence has little effect on the polarization degree and polarization state of the beam during long distance transmission [6-7]. Theoretically the crosstalk of orthogonal polarization can be ignored. Thus, Polsk has important research significance in the FSO [8-10], since it can expand the communication bandwidth.

In conclusion, a 60GHz ROF-FSO system with 4-PAM Polsk downlink signals is designed. One continuous light wave is modulated by 4-PAM and polarized, and beats with another clean laser signal to generate millimeter-wave signals. In the receiver, self-mixing zero-difference detection technology is used to demodulate high-frequency signals down-converted into low-frequency baseband signals. Through simulation, the optical spectra, RF

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spectrum, eye-diagram before and after transmission are measure, and the transmission performance of 10Gbit/s 4-PAM Polsk signal in RoF-FSO system is analyzed.

2 System

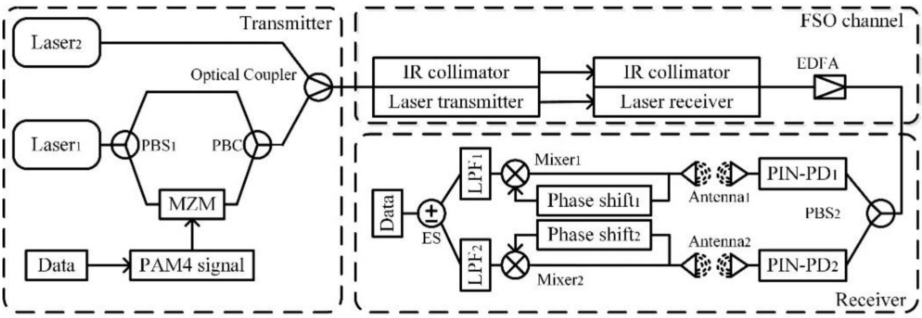

Fig. 1. Schematic diagram of system setup.

Figure. 1 depicts the schematic diagram of system setup for 10Gbit/s RoF-FSO system modulated by 4-PAM Polsk. In the transmitter, two continuous waves (CWs) with f_1=193.16THz and f_2=193.1THz are produced by two external cavity lasers (ECLs), and the frequency interval between them is 60 GHz. One CW is divided into two orthogonal polarization directions beams after passing through one polarization beam splitter. One part is modulated by a single-arm Mach-Zehnder modulator (MZM) using 10Gbit/s 4-PAM electrical signal, then recombines with another unmodulated beam through the polarization beam to form a polarized light. Through one symmetrical 3dB optical coupler, the modulated optical carrier is coupled with another optical carrier (193.16THz). Since the power of the optical signal will decay in different degrees after transmission in free space, the erbium-doped fiber amplifier (EDFA) is needed to compensate the transmission attenuation of optical signals. In the receiver, the polarization beam splitter divides the received optical signal into two optical signals that are orthogonal to each other. The 60 GHz millimeter wave is generated in the photodetector (PIN-PD) by two optical sidebands beating together. And transmission and reception of millimeter wave signals are realized by two standard horn antennas. The received millimeter wave signal is demodulated by using the self-mixing zero-difference detection technology, and two adjustable phase shifters are used to compensate the phase deflection between the two signals, which is conducive to reducing the influence of phase noise on the system. Since no local oscillator is used, the system cost budget is further reduced. After self-mixing demodulation, the high-frequency signal is filtered out by a low-pass filter (LPF), then differential reception is carried out to recover the original data information.

3 Results

Figure. 2 (a) and (b) show the time domain waveforms of 4-PAM Polsk signals before and after transmission in 1km free space. There are four level changes of 4-PAM signal, and each level carries 2bit information. As can be seen from the figure, although the waveform of 4-PAM signal has some distortion, it can still be clearly distinguished, and the 4-PAM signals waveform from the transmitter is similar to the receiver.

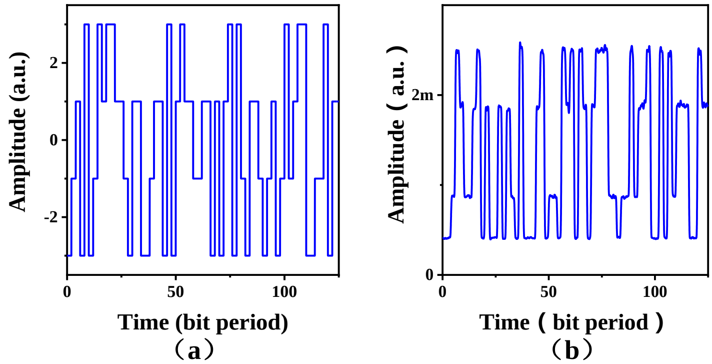

Fig. 2. (a) Time-domain waveform before transmission; (b) Time-domain waveform after transmission.

Figure. 3 (a) and (b) are the optical spectrograms before and after transmission. The frequency difference of two optical sidebands is 60GHz, indicating that the system has good frequency stability. Figure. 4 (a) shows the RF spectrum after PIN-PD, 60 GHz millimeter wave is clearly visible. Figure. 4 (b) shows the RF spectrum after differential reception, indicating that the high frequency signal has been filtered out and the baseband signal is obtained.

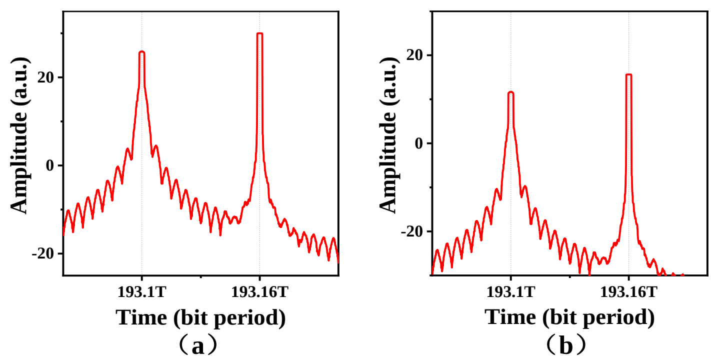

Fig. 3. (a) The optical spectrum before transmission; (b) The optical spectrum after transmission.

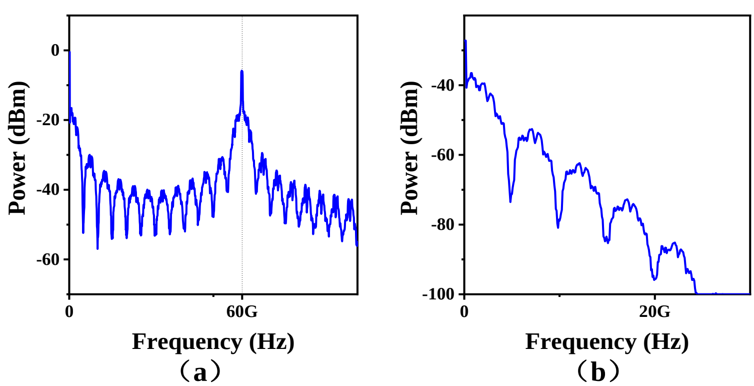

Fig. 4. (a) The RF spectrum after PIN-PD; (b)The RF spectrum after differential reception.

The eye diagrams under different transmission distances are shown in Figure. 5. It can be clearly seen that, compared with the back-to-back (BTB) case, the edge of the eye diagram after transmission in 1km free space has obvious thickening traces, but it can still meet the basic requirements of communication since the signal decision process can be easily realized in the receiver.

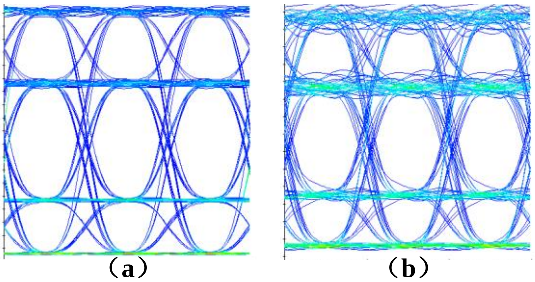

Fig. 5. (a) The measured eye diagram at the BTB case; (b) The measured eye diagram after transmission.

4 Conclusion

In this paper, we propose and design a RoF-FSO system, which can transmit 4-PAM Polsk signals with 1km downstream transmission distance. We analyze the transceiver and 10Gbit/s optical signals transmission performance through simulation experiment. The characteristics of 4-PAM signal before and after transmission are tested, such as time-domain waveform, optical spectrogram, RF spectrum and eye diagram. This scheme can further increase the system bandwidth, enhance the stability of the system transmission, and recede the impact of atmospheric turbulence in the future FSO transmission system.

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