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Simulation research on ROF system based on 8PSK and 16PSK modulation

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Abstract. Radio over Fiber (ROF) has the advantages of low transmission loss, huge bandwidth, resistance to electromagnetic interference and so on. It becomes a research hotspot in recent years. In this paper, the ROF system with suppression of odd sidebands based on Maher-Zehnder modulator (MZM) is proposed. The system uses Eight Hexadecimal Phase Shift Keying(8PSK) and Sixteen Hexadecimal Phase Shift Keying(16PSK) to modulate. Under different frequencies of RF signal, the spectrum diagram and constellation diagram are obtained after the transmission of 20km single-mode fiber(SMF). By analyzing the constellation characteristics of the received signal, it is proved that compared with the 16PSK signal, the 8PSK signal reduces the frequency of the modulated signal, saves the spectrum resources better, increases the capacity of the communication signal, and realizes the stable transmission.

1. Introduction

Radio over Fiber (ROF), which has the characteristics of high frequency radio wave and low loss of optical fiber, has realized high speed and large capacity broadband transmission, and can give full play to dozens of spectrum resources, which has become the research focus of many scholars in recent years. The generation of optical millimeter wave is one of the key technologies of ROF, while the optical carrier suppression modulation phase has higher bandwidth utilization and receiver sensitivity than single and bilateral band modulation, and it can avoid periodic fading and achieve stable transmission of the system. In order to meet the increasing large capacity requirements of users, multilevel signals with high spectrum utilization, can get more communication capacity than binary signals in the same bandwidth, and have been widely used. At present, low frequency band resources are scarce. How to reduce RF signals and transmit them effectively is also one of the research directions of ROF.

In view of the above problems, this paper proposes a suppression of odd-sideband ROF system based on Mach-Zehnder modulator(MZM). The system uses the Eight Hexadecimal Phase Shift Keying(8PSK) and the sixteen phase shift keying (16PSK) modulation. After the transmission of 20Km single mode fiber (SMF), the spectral map and constellation of the two modulation signals are compared under different frequencies of RF signal. By analyzing the constellation characteristics of the received signal, it is proved that compared with the 16PSK signal, the 8PSK signal reduces the frequency of the modulated signal, saves the spectrum resources better, increases the capacity of the communication signal, and realizes the stable transmission.

2. Analysis of system principle

2.1. Odd side band carrier suppression

The principle block diagram of the ROF system is shown in Figure 1. At the center station, the CW laser output from the light source is $E_0(\mathrm{t}) = \exp(jw_c t)$, W_C is laser frequency. V1 is a DC bias voltage of the upper arm of the MZM, V2 is the DC bias voltage of the lower arm of the MZM, V3 is the amplitude of the RF voltage in the upper arm, V4 is the amplitude of the lower arm RF voltage, and θ is the phase difference between the two arms. Take V1=0， V2=π， V3=V4， θ=0, Therefore, the signal after MZM modulation is:

$$E = \frac{1}{2}\alpha A(t)\exp(jw_c t)[\exp jm_n \cos wt - \exp(-\cos wt)$$

$$= \frac{1}{2}\alpha A(t)\exp(jw_c t)\times[\sum_{k=\infty}^{+\infty} j^k \bullet J_k(m_n)\exp(jkwt) - \sum_{k=-\infty}^{+\infty} j^k \bullet J_k(-m_n)\exp(jkwt)$$

Take $m_n = \pi / V_\pi \times V$,

$$E = jJ_1(m_n)\alpha_1\alpha_2 A(t)\exp(jw_c t)[\exp(-jwt) + \exp(jwt)$$

Where α is the optical insertion loss, A is the optical carrier amplitude, and J is the Bessel function.

2.2 8PSK signal modulation and demodulation

MPSK modulation is a kind of absolute phase shift modulation, which represents the input signal according to the M different phases of the carrier. The 8PSK modulation means that the upper sideband signals of the two first-order sidebands suppressed by the carrier , are averagely divided into 8 phases and then synthesized. As shown in Figure 2, the upper and lower two signals are orthogonal to each other, but the amplitude is different. On the demodulator, the orthogonal coherent demodulation is used.

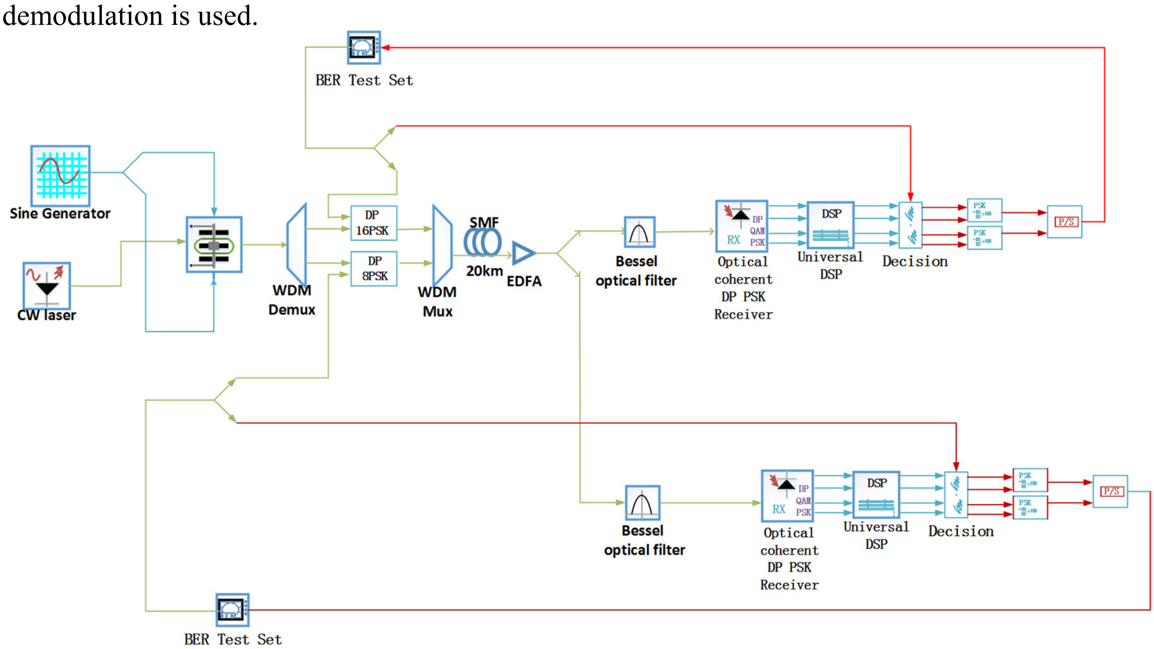

Fig. 1 Schematic diagram of the ROF system

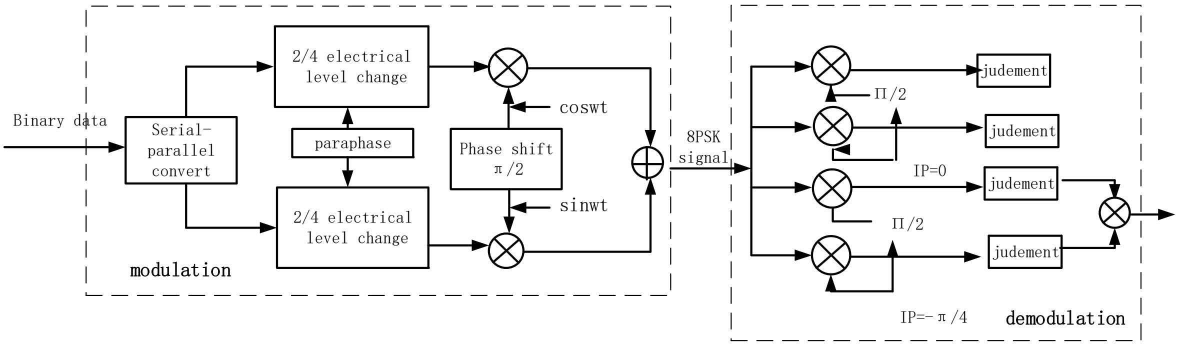

Figure 2 8PSK modulation and demodulation block diagram

2.3 16PSK signal modulation and demodulation

As shown in Figure 3, 16PSK modulation refers to make the signal data information (each symbol containing 4bit information) with the lower sideband of the carrier suppressed to carry out code transformation, and the serial-parallel conversion. Then the same two phases are used to map the constellation. Finally, the two output values are multiplied and added to get the 16PSK modulation signal. At the demodulation side, the demodulation process is the inverse of the modulation process.

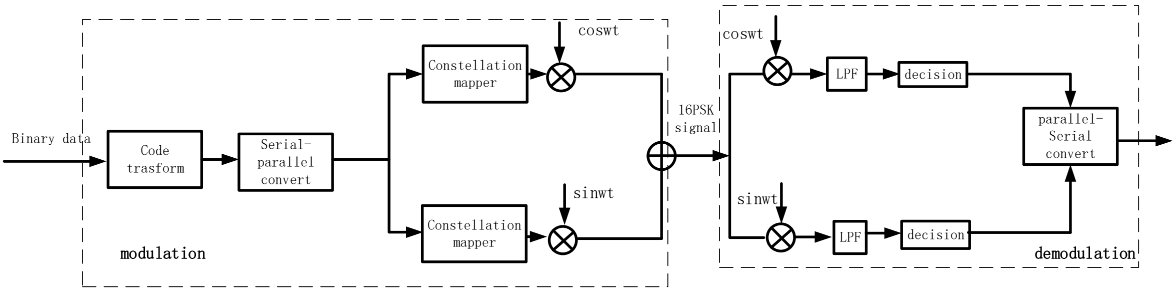

Figure 3 16PSK modulation and demodulation block diagram

3. system design and simulation results

In this paper, Optiwave is used to build a ROF system based on carrier suppression, as shown in Figure 1. At the center station, the center frequency of the continuous laser source is 193.1THz and the polarization angle is 45 degrees. The MZM with an extinction ratio of 30 GHz is driven by a 15 GHz and 20 GHz RF signal. The two DC bias voltages of the MZM are set to 0V, 4V, respectively, the modulation voltage is πV, and the RF voltage is 1V, so that the odd-subband side modulation signal is suppressed. The spectrum of this signal is shown in Figure 4(a). Under 15GHz RF signal conditions, the center frequencies of the two signals are 193.085 THz and 193.115 THz, respectively. In the 20 GHz RF signal conditions, the center frequencies of the two signals are 193.08 THz and 193.12 THz, respectively. Wave demultiplexer is used to separate the first-order sideband signals, and the data information modulated by 16PSK and 8PSK are respectively loaded, and then the multiplexer transmits the one-way transmission signal to the base station through a 20Km single-mode optical fiber. The spectrum is shown in Figure 4. (b) . At the base station side, two signals are filtered out through the Bessel bandpass filter. Coherent demodulation restores the original data.

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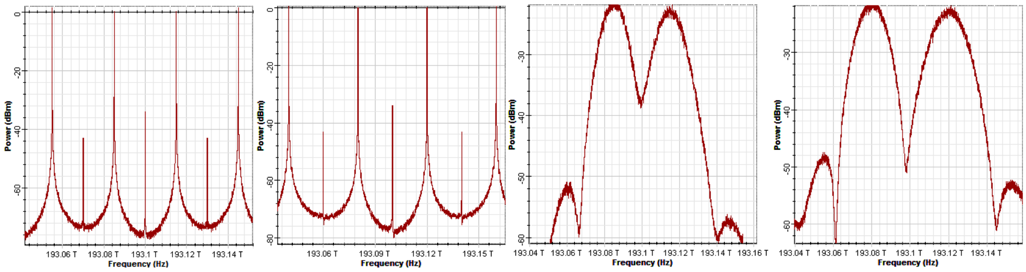


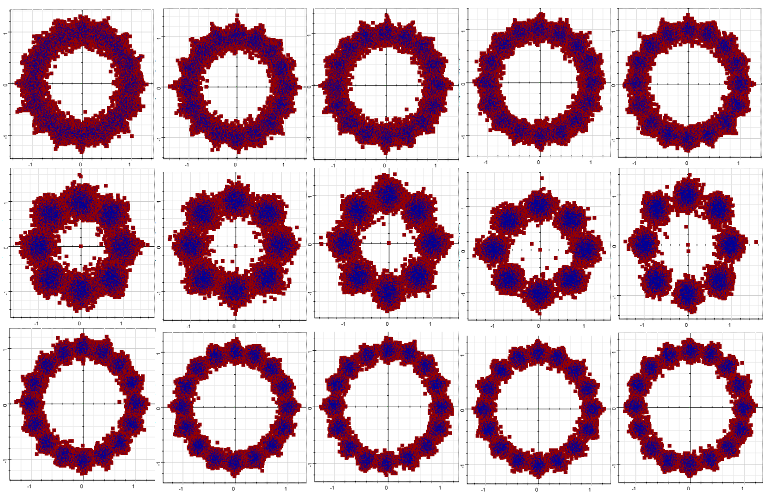
（a） （b）

Figure 4 (a) Spectral diagrams of odd-order sideband suppression signals for RF signals at 15 and 20 GHz, respectively;
(b) spectrum diagrams of the two modulated signals arriving at the base station when the RF signals are respectively 15 and 20 GHz;

Figure 5 shows the corresponding constellation diagram of 8PSK and 16PSK modulated signals when the RF signals are 15GHz (a) and 20GHz (b), respectively. From Figure 5(a), it can be seen that the 16PSK constellation is fuzzy and cannot transmit the useful signal normally. Although the 8PSK constellation point is slightly degraded, it can still effectively and reliably transmit data information; As can be seen from Figure 6 (b), the 16PSK constellation map has a phase ambiguity when the OSNR is less than 25, and cannot properly transmit useful signals. When the OSNR is greater than 25dB, the constellation phase is gradually clear and the phase has slightly error, but can be transmitted normally; 8PSK constellation points is obviously better than 16PSK signal, and its constellation map can achieve error-free transmission requirements;

4. Conclusion

In this paper, the ROF system with suppression of odd sidebands based on Maher-Zehnder modulator is proposed. The system uses Eight Hexadecimal Phase Shift Keying and Sixteen Hexadecimal Phase Shift Keying to modulate. Under the 15GHz and 20GHz RF signals conditions, the spectrum diagram and constellation diagram are obtained after the transmission of 20km single-mode fiber. By analyzing the constellation characteristics of the received signal, it is proved that compared with the 16PSK signal, the 8PSK signal reduces the frequency of the modulated signal, saves the spectrum resources better, increases the capacity of the communication signal, and realizes the stable transmission.



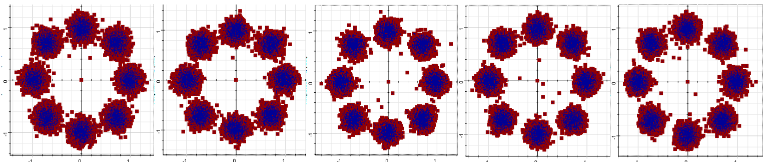


Figure 5(a) 8PSK, 16PSK signal constellation at 15GHz

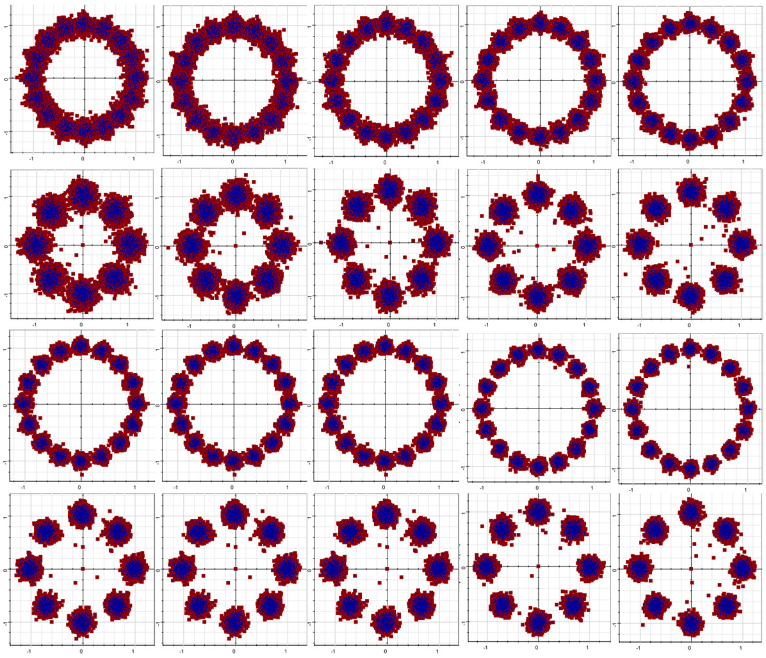


Figure 5(b) 8PSK, 16PSK signal constellation at 20GHz

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