The Estimation of Digital Adaptive Carrier Phase in Multi-Level Phase-Shift Keying Coherent Optical Communication Systems

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Abstract: At This Stage, China's Science and Technology Continue to Develop, Optical Fiber Technology Continues to Improve, and the Loss is Gradually Reduced, Which is Widely Used in Communications. At Present, Optical Fiber Communication Has Basically Been Popularized. However, the Application of Multi-Level Phase Shift Keying Coherent Optical Communication System Still Has Some Problems, and It is Difficult to Meet the Actual Production and Living Needs. Based on This, This Paper Elaborates on the Relevant Theory and Analyzes the Carrier Phase Estimation. Finally, a Multi-Level Phase Shift Keying Coherent Optical Communication System is Built and Digital Adaptive Carrier Phase Recovery Simulation is Carried out.

1. Introduction

1.1 Literature Review

The combination of digital signal processing and coherent optical communication has been rapidly developed in recent years, and the use of DSP algorithms can efficiently compensate for each damage in the fiber communication link. With the increasing demand for communication bandwidth, high-order modulation format-dependent modulation methods are considered to be able to efficiently satisfy high-capacity transmissions, but for high-order modulation formats, it is for transmitting lasers and The phase noise caused by the two lasers is very sensitive. For this reason, the corresponding carrier phase estimation algorithm must be studied in depth (Ma et al, 2019). Zhang Qi and other scholars have obtained the performance of eight carrier phase estimation algorithms in 16QAM systems for the linewidth tolerance and hard core complexity of the eight carrier phase estimation algorithms (Zhang and Wang, 2016). Zhao Lun and other scholars have studied the computational complexity of the existing blind phase search algorithm, and obtained a second-order carrier corresponding algorithm based on the improved orthogonal phase shift keying correlation partition algorithm (Zhao et al, 2016). Zhou Zhili studied the principle of the level of coherent reception systems in different forms, and studied the whole process of DSP algorithms in coherent optical communication, and obtained how to improve the carrier phase estimation in the aspect of coherent optical communication systems (Zhou et al, 2018).

1.2 Research Purposes

With the emergence of high technologies such as the Internet of Things, the Internet, big data and cloud computing, and the continuous development of multimedia such as digital HDTV and ultra-high definition video, people's demand for data sharing and storage is increasing. The traditional coherent communication system can no longer meet the needs of current social development and people's needs. At this stage, people have made breakthroughs in the research of optical fiber communication, and the development of optical communication has realized the large-scale transmission of some data information. However, in order to further meet the needs of people and the needs of social development, achieving high-speed transmission of data information over long distances and large capacity is still an urgent problem to be solved in current fiber-optic communication research. Based on this, the carrier phase estimation is studied in this paper, and the carrier phase recovery simulation of the multi-level phase-shift keyed coherent optical

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communication system is carried out, in order to provide a useful reference for the digital adaptive carrier phase estimation of the relevant optical communication system.

2. Overview of Relevant Theory

Phase shift keying. A modulation technique that uses carrier phase to correlate input signal information. It is mainly divided into two methods: relative shift and sensory phase shift (Zhang and Dong, 2017). The absolute phase shift is a phase modulation in which the phase among the unmodulated waves is used as a reference in the entire process.

Direct detection of optical communication systems. The optical signal received by the receiver and the local oscillator light signal generated by the local oscillator laser are passed through an optical mixer, and outputted by the photodetector, and finally the original information is recovered by demodulation. At present, the traditional optical communication system in China adopts the form of direct detection of intensity modulation, which should be simple in structure and relatively low in implementation cost, so it is commonly used in people today, and it is used in commercial applications. A conventional optical communication system has a receiving end, a transmitting end, and a transmission link. The transmitter at the transmitting end uses an intensity modulation mechanism whereby the input electrical signal is converted into an optical signal using intensity modulation in the driver circuit (Zhou et al, 2018). In turn, the output source can be efficiently modulated into the fiber for fast output. However, the receiver needs to quickly convert the received optical signal into an electrical signal, and then amplify the signal. The main purpose of this is to improve the signal-to-noise ratio to improve the overall performance of the system, and finally the recovery output of the original signal. However, the current modulation directly detects the optical communication system, although it can be realized for the transmission of a larger capacity, and has the advantages of easy modulation and demodulation, but the current system uses a light source composed of a frequency band, and the light source Not a single source. It is only suitable for the amplitude parameter of the light source during the whole intensity modulation process, and belongs to the noise communication system. This limits the relay distance and transmission distance in the system, which greatly hinders the rapid development of the optical system.

The coherent optical transceiver in the coherent optical communication system has the advantages of large communication content, high sensitivity, and various related aspects such as various debugging forms. For the entire coherent optical communication system, the basic implementation principle and the difference of the traditional optical communication system in China focus on the two aspects of the mixer Fen local oscillator laser used in the receiving end. However, both the optical signal and the local oscillator signal of the high attack rate increase the signal power after mixing, which increases the signal-to-noise ratio of the system a lot, and the acceptance sensitivity also increases greatly. At the same time, the digital signal processing block of the system can effectively compensate the relevant channel damage formed by the optical fiber and can eliminate the related noise during the transmission process, thereby effectively recovering the relatively standard signal information.

3. Carrier Phase Estimation

3.1 M Power Phase Estimation

The current algorithm for M-th power carrier phase estimation is still the pre-feedback carrier recovery algorithm. It is still used continuously in the phase shift keying modulation format, and it is also a relatively common phase estimation algorithm. The specific idea of such an algorithm is that the computer receives the M power of the optical signal to remove the phase modulation information of the optical signal, thereby recovering the original data information. The specific operation process of the algorithm is to first calculate the M-th power of the optical signal to achieve the modulation phase of eliminating the data length, and secondly calculate the phase rotation rate to obtain the frequency offset of the transmitter and the local oscillator. After the frequency offset is removed, the signal is subjected to the M-th power operation to achieve the purpose of removing the data modulation phase. The average of the different adjacent symbols is then evaluated to estimate the laser phase noise based on the average.

3.2 Blind Phase Search Algorithm

At present, the blind phase search algorithm is still adapted to different modulation formats, and the process mainly divides a plurality of test phases in one region, thereby performing phase estimation. Therefore such an algorithm has a relatively high estimation accuracy. The main idea of such a calculation method is to first assume the test phase to appear, and then multiply the received light source signal and the test phase, and then make a difference. Finally, the phase noise estimate is estimated by a large number of operations to find the relatively smallest modulus.

At present, the blind phase thinning algorithm has high efficiency to compensate the phase noise in the 16QAM signal, and also adapts to the advantages of the high-order QAM modulation format, but this will lead to the corresponding disadvantages of the increase of computer complexity. At present, some scholars think that this algorithm is the phase that may occur when the received signal is in the process of rotating on the complex plane, and then the calculation of the average value, the decision and the square of the rotated signal. This will lead to no obvious way to highlight the advantages it has in the actual use.

3.3 New Segmentation Algorithm

The blind phase search algorithm is mainly based on the idea of the Euclidean distance algorithm to realize the carrier phase noise estimation. In addition, these algorithms can effectively adapt to the high-order QAM modulation format, and there are some noise estimation algorithms among the pre-feedback carrier phases. It is also suitable for high-order QAM modulation formats. However, there is a QPSK segmentation algorithm, and the constellation point phase information of the QAM signal as a whole can be used, but this will increase the computational complexity. At present, when the QPSK segmentation algorithm makes phase noise estimation for the 16QAM modulation format, the signal-to-noise ratio of each ring in the 16QAM constellation point is often different, resulting in lower estimation accuracy of phase noise. Therefore, using the modified M-th power phase estimation algorithm, the idea of this calculation method is effectively combined with the maximum likelihood estimation to achieve the estimation accuracy of the phase noise improvement calculation method.

4. System Simulation

The coherent optical communication system designed in this paper mainly includes five parts, namely error analysis and photoelectric detection decoding, DSP processing, coherent receiving end, transmission link and transmitting end. The optical signal is transmitted by the transmitting end and finally reaches the signal receiving end. Through the low-pass filter and the electric amplifier, the optical signal is sent to the DSP processing module, converted into an electrical signal via the photodetector, and finally subjected to error analysis.

In the DSP processing module, the optical signal passes through the fiber link and is affected by the dispersion of the fiber, resulting in waveform distortion. Therefore, it is necessary to compensate for the received optical signal. Through compensation, the carrier phase estimate will be restored to the original optical signal and transmitted to the DSP block. In this module, the optical signal is first converted to a digital optical signal by analog-to-digital conversion. Thereafter, the system performs dispersion compensation and polarization mode dispersion compensation on the converted optical signal. Finally, the optical signal is digital-to-analog converted and converted into an electrical signal input to the photodetection module.

Through the simulation of the coherent optical communication system, the following conclusions are drawn. The optical signal is transmitted in the fiber link, and is affected by various factors such as fiber dispersion, which causes phase deflection and symbol interference of each constellation point of the optical signal, and the overlapping portion is difficult to distinguish. When the DSP module processes the optical signal, the constellation points obtained are clearer. After CD compensation, the amplitude of the rotation of each constellation point of the optical signal shows a downward trend, and the symbol interference also shows a small trend, and the overlapping parts of the constellation points can be distinguished. After PMD compensation, the rotation amplitude of each constellation point of the optical signal is greatly reduced, and the interference between symbols is also significantly reduced, and the overlapping area between the constellation points is relatively small.

In this paper, a multi-level phase shift keying coherent optical communication system is built and the carrier phase recovery of the system is simulated. At the same time, the DSP module in the simulation system is introduced. In view of the interference of optical signals in the transmission of optical fiber links, this paper compensates in the simulation system, and analyzes the simulation results, and then obtains the best simulation parameters, and performs BPS phase recovery simulation.

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