Research on Coherent Receiving Technology of Free Space Optical Communication

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Abstract: Free Space Optical Communication Generally Refers to Long-Distance Optical Wireless Communication with Laser as Carrier and Atmosphere as Transmission Medium, Which is Commonly Used in Satellite Communication, Uav Communication, Emergency Communication and Other Applications. Compared with Radio Frequency Communication, It Has the Advantages of High Bandwidth, Strong Confidentiality, Low Deployment Cost, No Spectrum License Plate and So on. However, the Propagation of Laser in the Atmosphere is Easily Affected by Atmospheric Turbulence and Weather Conditions, Resulting in the Power Fading and Signal Distortion of the Received Signal, Which Makes the Communication Performance of the System Decline. in Order to Resist This Kind of Interference, on the One Hand, the Redundancy and Reliability of Communication Can Be Improved by Coding and Other Technologies, on the Other Hand, the Receiver Sensitivity Can Be Improved. in This Paper, the Free Space Communication Channel Model is Summarized Based on the Atmospheric Turbulence. Aiming At the High-Speed and High-Sensitivity Receiver, the Coherent Receiver Based on Digital Signal Processing Technology, the Coherent Receiver Based on Single Photodetector and the Multi Aperture Receiver Are Discussed and Experimented One after Another.

1. Introduction

Nowadays, People's Demand for Communication Continues to Grow, and New Services Require Higher Speed, More Reliable and More Secure Communication Links [1]. the High-Speed Communication between Mainboards and Chips in Data Center, High-Speed Mobile Communication, Triple Play and Higher Quality Streaming Media Services All Promote People's Continuous Research on Communication System. in This Context, Wireless Communication Technology Develops Most Rapidly, Mobile Phones and Tablet Computers Have Become People's Daily Equipment; China is about to Enter the Fifth Generation Mobile Communication Era. When We Refer to Wireless Communication Technology, We Usually Refer to Wireless Radio Frequency Communication Technology, Including Indoor Wifi Application, Mobile Phone Communication in the City, Long-Distance Radio Call, Satellite Communication [2]. However, the Communication Speed and Capacity of the System Are Limited by the Frequency Band of Radio Frequency Signal. Moreover, Due to the Propagation Characteristics of Radio Frequency, the Specific Frequency Band Needs License Plate Management, While the Free and Open Frequency Band Faces the Problem of Co Frequency Interference. Because of the High Frequency of Optical Band, the Growing Communication Demand Makes People Begin to Study the Feasibility of Wireless Communication in Optical Band. Optical Communication Starts from Signal Transmission, Which Can Be Considered as the Embryonic Form of Long-Distance Communication, Optical Wireless Communication, and Optical Wireless Communication (Owc). the Research of Modern Optical Communication Began in 1810 When Carl Friedrich Used the Communication Demonstration of Reflector and Sunlight [3]. the Research of Telephone Communication and Military Application Was Carried out. in the 1960s, with the Invention of Light Emitting Diode (Led) and Laser, Optical Wireless Communication Began to Use This Kind of New Light Source, But Limited by the Influence of Light Source Divergence and Atmospheric Turbulence, the Communication System

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Has a Limited Propagation Distance. in the 1970s, with the Emergence of Low Loss Optical Fiber, the Focus of Optical Communication Research Turned to Optical Fiber Communication (Ofc) [21. through Decades of Development, the Optical Fiber Communication System in the Existing Communication Network Has Become the Most Important Core Network Link Besides the Wireless Access Network Communication System.

2. Coherent Optical Communication System

Coherent optical communication system combines coherent detection technology, digital signal processing technology and advanced modulation format, so the optical communication system has greater transmission bandwidth and higher sensitivity [4]. However, the system can resist the damage of optical transmission system. In the coherent optical communication system, the signal can be loaded into the amplitude, frequency, phase and polarization vector of the optical signal, mixed and interfered with the local laser at the receiving end, and then the electrical signal can be obtained through the photoelectric detector. By combining with digital signal processing, all information about amplitude, frequency, phase and polarization is recovered, and a higher-level modulation format is used in the optical communication system. In addition, a new optical angular momentum transmission technology suitable for free space transmission is proposed.

3. Key Technologies of Space Optical Communication

3.1 Atmospheric Channel Simulation

The main reason of channel degradation in cosmic optical communication is atmospheric current. Because of the complexity of atmospheric channels, modeling them has always been a very challenging problem. Many researches focus on the method of simulating indoor air channel[5]. By simulating the current in the atmosphere, we can avoid the shortcomings of outdoor experiment cycle and the difficulty of repetition, so as to speed up the experiment process of cosmic optical communication technology. According to the atmospheric pressure theory, the indoor atmospheric large current simulation can be realized by embedding the spatial light modulator into the phase optical network method.

3.2 Receiving Technology

3.2.1 Diversity Technology

Spatial diversity reception has two meanings: one is decentralized reception, that is, the receiver has the same information and independently receives multiple fading signals. Appropriate combination of multiple received independent information to improve system performance and reduce the impact of fading. The model used in the study was multiple transition tasks. The basic principle is multiple reception of the same signal. The received signals experience atmospheric channels in different spaces, so there is no correlation between the channels, that is, there is no reception. Multiple signals experiencing different fading [6]. By combining these multiple signals, the algorithm can effectively improve the outage probability of the connection and reduce the noise comparison and error performance of the received signal.

3.2.2 Coherent Receiving Technology

The existing space modulation communication system under the direct intensity modulation system has weak background light interference performance and low detection sensitivity. Coherence detection technology, receiver sensitivity, transfer distance and anti background noise performance can be greatly improved, so it is particularly suitable. The coherent optical communication technology of spatial optical communication system is used for the refresh rate of gigabits per second. It is the information of optical phase, amplitude modulation and polarized light. In order to be used, it is implemented according to various complex high-order modulation formats. The frequency and phase compensation of the received signal of the receiver can be used to realize

offset speculation and phase recovery algorithm [7]. When the laser transmits in the atmosphere, its power is not only attenuated, but also its phase is distorted, which leads to the degradation of the beam quality and the phase distortion at the receiving end. Digital phase receiver technology can be used to compensate the received signal at the receiving end, so as to improve the dislocation performance. In addition, the coherent mismatch compensation algorithm can compensate the degradation of frequency, phase and polarization state, and provide guarantee for high sensitivity coherent reception.

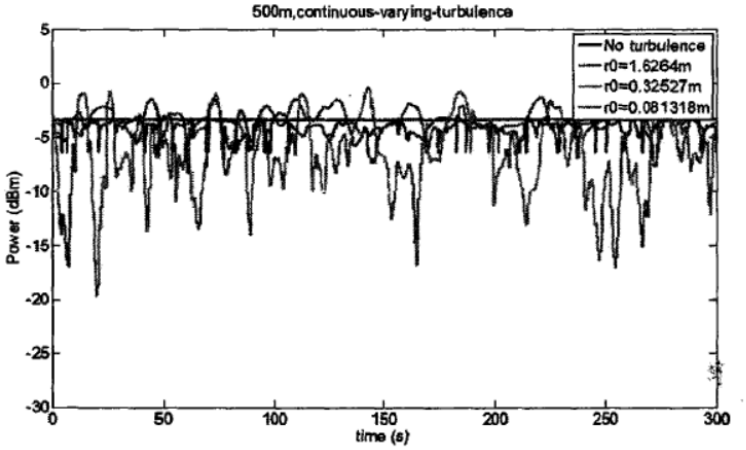

Fig.1 Received Power When Analog Distance is

4. Development of Cosmic Optical Communication in China

In the 19th century, China began to study satellite laser communication. The main research interests of cosmic optical communication in China are: Beijing Post University, Changchun University of science and technology, electronic science and Chengdu University, Beijing University, Tsinghua University, Harbin University of technology, China Aerospace Research and development center. Research Institute of China Electronic Technology Corporation, Chinese Academy of Sciences, etc [8]. In January this year, Harbin University of technology carried out ground laser link experiments on ocean-2 satellite. In this study, ocean-2 satellite platform is used as the test platform, using the communication link between satellite and ground. In order to establish the information as the laser of career, the two-way laser communication link between satellite and ground is used for testing, with a transmission distance of about 30 km. This is the first satellite optical communication link orbit test in China, which provides an important demonstration basis for the development of satellite optical communication technology in China. The Optical Engineering Department of Changchun University of science and technology studies the optical system of satellite ground optical communication based on porous array antenna. Adopt architectural design. The diversity of signals received by spatial diversity antenna greatly improves the reliability of data transmission. In 1995, the State Key Research Institute of the regional optical fiber communication network and the new optical communication system of Peking University studied the extension effect of cosmic coherent optical communication. The results show that the maximum heterodyne efficiency can be achieved by optimizing the radius of two overlapping beams according to the atmospheric current condition and detector radius. He points out that current in the atmosphere can significantly reduce the efficiency of telomere detection. At the same time, compared with the fully coherent beam, the partially coherent beam is less sensitive to the change of current condition. Therefore, in the case of receiver mismatch, the reliability of partially coherent beams is higher than that of completely coherent beams [9]. China Electronic Technology Research Institute (hereinafter referred to as the Institute) of the Group Co., Ltd., research and development of wireless laser communication technology, developed relevant products, operators, military, electric power, public security, petrochemical, transportation users are widely used. From the beginning of this year, we started a series of equipment for operators; the communication rate is the communication distance of their own products. It has obtained the network license and is widely

used. The overall availability of equipment can meet the needs of operators. Since the beginning of this year, the Institute has provided more than one equipment supporting service for China Mobile, China Communications, electric power, civil aviation, oil, military, scientific research institutions and other users. The communication speed is the sum and the communication distance is the number. In January, a long-distance space optical communication transmission experiment was carried out. The communication distance and transmission speed reach the communication link, which is more than half of the span of Guilin's urban area. The field of vision is many kilometers, and the continuous test time, hours and minutes, the bit error rate cannot meet the actual application conditions.

5. Research on the Channel of Cosmic Optical Communication

5.1 Atmospheric Channel Composition

The wavelength of light is much smaller than that of electric waves. It has a very large directivity in the process of propagation, is a very small diffraction loss, can move a very long distance with a small power. But at the same time, the beam is easily affected by the atmosphere in the transmission process. In laser communication, the beam propagation in the atmospheric channel is affected by various atmospheric factors. They reduce the communication link margin individually or collectively, and may cause signal loss in serious cases.

5.2 Atmospheric Reliability Theory

According to the theory, when light passes through the earth's atmosphere, the change of the refractive index of the atmosphere changes the path of light transmission, resulting in the disappearance of illuminance, beam drift and coherence. From the receiving end, it includes light intensity change in space and time, angle of attack jitter, focus and speckle, large-scale beam displacement, image jitter, beam drift and speckle. The beam offset is caused by the angle offset of the receiving beam relative to the line of sight. The focusing beam can be separated by passing over the receiving lens. As a result, the receiver cannot receive the signal. Beam divergence is caused by small angle scattering, which results in the increase of beam divergence angle and the decrease of spatial power density of receiver. Beam flicker is caused by small-scale interference on beam cross-section, and causes high-speed, millisecond level spatial power density jitter at the end of photodetector. Due to the change of the angle of the received beam, the image jitter appears as a random change in the size of the convergence point in the photodetector of the receiver. The air ruiliu will reduce the communication quality and even cause communication interruption in serious cases.

6. Conclusion

High sensitivity, high speed and low cost receiver is the research topic of free space optical communication. Due to the limitation of research time, experimental conditions and author's level, there are many places to further study this topic.

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