

## Research on Ultra-Wideband Signal Transmission in Optical Fiber Communication System

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**Abstract:** Optical Fiber Communication System is the Most Popular Communication System in the World. However, It Requires Higher Communication Signal. Ultra-Wideband (Uwb) Signal is Commonly Used in Optical Fiber Communication System Because of Its Characteristics of No Carrier, Strong Anti-Interference Ability and Fast Transmission Speed. However, Uwb Signal Has a Large Energy Consumption and Cannot Be Transmitted over Long Distances, Which Limits the Application Range. But through the Optical Fiber Communication System Can Effectively Avoid This Shortcoming, Lengthen the Transmission Distance. Take into Account This, This Paper Takes an Optical Fiber Transmission System Based on Ultra-Wideband Signal Technology as a Case Study, and Analyzes the Principle, Composition, Design and Other Aspects of the System. the Feasibility and Effectiveness of This Transmission Mode Are Verified by Corresponding Experiments. the Details Are Reproduced Below.

### 1. Introduction

The biggest advantage of optical fiber communication system lies in the large capacity, long transmission distance, and can ensure the safety of transmission. Therefore, it widely used in various fields. Through ultra-wideband signals, signals transmitted through optical fiber communication system can be displayed more clearly and intuitively. In addition, it reduces shielding interference, increases transmission capacity and improves the reliability of optical fiber communication system. Based on this, it is necessary to carry out the research of ultra-wideband signal transmission in optical fiber communication system.

### 2. Ultra-Wideband Technology

UWB technology and traditional technology have many advantages. In essence, UWB technology is a typical carrier free communication technology. It mainly realizes data transmission through narrow and wide pulse of non-sinusoidal wave, whose width can reach nanosecond level. Therefore, UWB technology occupies a wide spectrum in the process of data transmission. In UWB communications, the highest frequency is usually expressed as  $f_m$  and the lowest frequency is usually expressed as  $f_L$ . UWB signal broadband is  $(f_m - f_L)$  and its relative width is expressed by the following formula:

$$\text{Relative width} = 2 \frac{f_m - f_L}{f_m + f_L} = 2 \frac{f_m - f_L}{f_c}$$

In this formula,  $f_c$  represents the UWB signal transmission frequency. In the specific transmission process, the relative width of -10db is more than 20%, and the frequency greater than 1.5ghz is UWB, which has a very wide range of applications in high-speed and short-range radio communication. Compared to traditional broadband, UWB signal has a wider frequency band, and its emission power is limited at different power levels.

### **3. Characteristics of Uwb Technology**

#### **3.1 Simple System Structure.**

The communication mechanism of traditional radio signals is that the carrier state is changed by changing the frequency or power of the carrier wave in a specific range to achieve the purpose of information transmission. However, when UWB signal is transmitted in optical fiber communication system, it can communicate without carrier wave, which reduces the complexity of UWB signal transmitting and receiving structure. It mainly transmits signals through pulses. In the specific communication process, no up-conversion support is needed. The price of the two-pulse transmitter is also relatively low, which reduces the communication cost.

#### **3.2 Low Transmitting Power.**

Compared with wired communication system, wireless communication system also has some limitations. The reason is that radio waves generally have a passionate openness in the process of transmission. In addition, ultra-wideband signal running power is relatively small, and its width is mainly above 1GHz. Therefore, it can hide in other signals and noise. In general, UWB signal in short distance wireless communication, as long as the width of signal broadband is reduced, the transmitting power of the UWB transmitter can be promoted below 1Mw. In addition, the transmitted power frequency density of the transmitter should be lower than the -41.3dbm /MHz stipulated by FCC. Therefore, when ultra-wideband signals are transmitted in the optical fiber communication system, the interference generated is almost the same as broadband white noise, which greatly improves the confidentiality of signal transmission and makes it difficult to effectively intercept. In addition, it can also effectively alleviate the current shortage of wireless spectrum resources, and improve the comprehensive utilization rate of China's existing wireless spectrum on the basis of ensuring signal transmission safety and efficiency.

#### **3.3 High Multi-Pathway Resolving Power.**

In a wireless communication system, radio-frequency signals are mostly continuous signals. In the process of multipath transmission, transmission time will be reduced. Thus affecting the speed and quality of signal transmission. Research and application examples at home and abroad show that UWB signal has strong multipath resolution ability when transmitted in optical fiber communication system. The main factor is that ultra-wideband signal uses narrow-band pulse as medium, which has very strong spatial and temporal distribution ability, and can obtain relatively strong anti-multi-path fading ability. In the explicit transmission process, if the product of multipath pulse width and radio propagation speed exceeds the furthest transmission distance, it will overlap in time. Relevant studies show that in the multipath transmission of UWB signals, the fading of ordinary radio signals is between 10dB and 30dB, while that of UWB signals is less than 50dB. It can be seen from this set of data that UWB signal communication performance and channel propagation and multipath have great influence. Therefore, in the specific transmission process, it is necessary to conduct in-depth research on the transmission environment, so as to more accurately predict the performance of UWB signal communication system, and design the transceiver performance and parameters based on this [1].

#### **3.4 High Transmission Rate.**

With the continuous development of China's communication technology and information technology, communication has gradually become intelligent, intelligent, digitized and diversified, and the speed of information transmission has also been improved. The communication frequency is no less than 50Mbps, providing technical support for the transmission of data and information of commercial business and multimedia business. However, the transmission rate of conventional communication cannot meet the requirements of big data and high power information transmission. UWB signal can greatly improve the data transmission rate due to its strong anti-multipath fading ability. Although UWB signal transmission power spectrum density is relatively low, the transmission rate is as high as 100Mbps, which can basically meet the needs of all walks of life for

data transmission.

### **3.5 Large Channel Capacity.**

When UWB signal is transmitted in optical fiber communication system, it mainly adopts the method of time-hopping address-code modulation to transmit pulse. The whole transmission process is similar to CDMA system, and the ability of resisting multipath fading is also strong. Six transmitters can simultaneously transmit UWB signals in a range of 10m, each with a transmission rate of 50Mbps. When 6 transmitters are running at the same time, the total transmission and transmission rate can reach 300Mbps, and the communication capacity can also reach more than 1000kbit/s/m<sup>2</sup>, which is incomparable with the traditional GSM system and CDMA system. Properly applied, UWB signals can support the simultaneous use of tens of thousands of users in an area [2].

### **3.6 Interference and Anti-Interference.**

When ultra-wideband signals are transmitted in optical fiber communication system, they can exist in combination with narrowband systems with the same spectrum. In addition, through scientific and reasonable design of UWB signal waveform and control of pulse width, the interference between UWB signal and signal in the spectrum can be effectively reduced, so as to ensure the efficiency and security of transmission.

## **4. Research on Optical Fiber Communication System Based on Uwb Signal**

### **4.1 System Design.**

Ultra-wideband signal optical fiber communication system structural composition is relatively complex, involving many modules. It is mainly composed of transmission module, fiber receiving module, fiber and other structures.

#### (1) Ultra - wideband implementation scheme.

The communication frequency of UWB signals is between 100MHz and 40GHz, covering almost all the bands, which puts forward higher requirements for broadband matching and corresponding isolation measures of microwave network. Therefore, the symmetric double - sector communication can realize UWB and high isolation communication. For broadband matching for optical devices, since its equivalent impedance is not  $\sqrt{2}$ , a stepped impedance matching network can be used to obtain good amplitude and performance in the specific communication process.

#### (2) Design of optical emission module.

In the ultra-wideband signal optical communication system, the main function of the optical emission module is to convert the ultra-wideband signal into an optical signal scientifically and reasonably. The core component of this module is m-z external modulator. There are two common modulation methods. One is relatively common direct modulation, which can be used when the UWB signal frequency reaches 26.5GHz; the other is external modulation. When the UWB signal frequency reaches 70GHz, external modulation must be adopted. In addition, in the specific design process of the optical emission module, appropriate modulation methods should be selected according to the actual operation of the system to ensure that the system has good in-band flatness [3].

#### (3) Design of optical receiver module.

The main function of the optical receiver module is to convert the maintenance optical signal into UWB microwave signal. This module is mainly composed of optical path adaptive module, optical detector, and broadband matching and so on. According to the actual operation of the system in Xihu District, reasonably dark current, capacitance and other parameters are selected [4]. According to the actual test results, the microwave impedance matching circuit matched with the optical receiving module is designed, so as to maximize the efficiency of optical information conversion to electrical signals, reduce unnecessary transmission losses, and promote the efficient demodulation of microwave signals to avoid linear distortion.

## 4.2 System Characteristics Analysis and Development Results.

(1)The relationship between output light power and bias voltage of external modulator

M-Z external modulator itself has serious optical loss. For example; optical loss of common LiNbO3 modulator is 3-sdb, and the optical power can be calculated as follows:

$$P_{MO} = \pi T_{FF} \times P_1 V_M / (2V\pi)$$

In this formula,  $P_{MO}$  represents the light output power of the modulator,  $T_{FF}$  represents the light transmission efficiency, and  $P_1$  represents the output power of the light source.  $V\pi$  represents the half-wave voltage in the system operation, and  $V_M$  represents the dc bias voltage added to the electrode on the external modulator. From this formula, it can be seen that if the number of  $T_{FF}$  is 1,  $P_1$  is 40mW and  $V\pi$  is 5V.

(2) Noise coefficient analysis of externally modulated optical fiber transmission system.

In ultra-wideband signal optical communication system, in order to improve the efficiency and security of communication, it is necessary to select high power external modulator link. DFB cw laser is usually used as the light source. Compared with other light sources, the line width of DFB light source is relatively small [5], only 1MHz. Therefore, in the specific transmission process, the noise intensity is also relatively small. Ultra-wideband signals in the operation of the optical fiber communication systems, optical modulator maximum transmission 2. Efficiency is 0.5, the impedance of 50  $\Omega$ , relative noise is - 163 DBC/Hz, absolute temperature is 290 k. Under the condition of different half-wave voltage, the relationship between noise coefficient and optical power in the external modulator link is shown in figure 1:

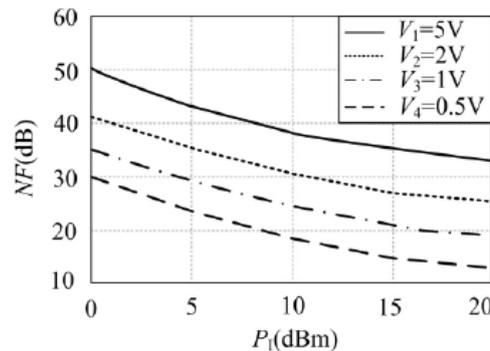


Fig.1 Relation between Optical Power and Link Noise Coefficient

It is clear from figure 2 that the light power is inversely proportional to the noise generation coefficient. Therefore, the higher the output light power is, the lower the noise coefficient in the external modulator link [6].

(3)Research results.

In the operation of ultra-wideband signal optical fiber communication system, the electrical parameters are: the working frequency is between 100MHz and 40GHz, the 1dB input compression point is -10dbm, the flatness within the band is  $\leq 3$ dB, and the noise coefficient is 39db@20ghz. System test results show that all electrical parameters are in the allowable range and meet the actual operational requirements.

## 5. Summary

To sum up, this paper analyzes the ultra-wideband signal transmission in optical fiber communication system based on theoretical practice. The analysis results show that this system has the characteristics of excellent performance, high reliability, convenient use and high safety factor. It can effectively meet the needs of radar, communication and electronic countermeasures, and has a very pronounced development prospect. It is primarily used in radar, communication, biomedicine,

ultrasonic nondestructive testing, distributed fiber optic testing, mass spectrometry, high energy physics, and high voltage local amplifier monitoring and other fields. It is worth popularizing widely.

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