OPTICAL COMMUNICATION SYSTEMS OPTICAL TELECOMMUNICATION TECHNOLOGIES

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ANNOTATION

Optical fiber (dielectric waveguides) has the highest bandwidth among all existing means of communication. Fiber-optic cables are used to create fiber-optic communication lines that can provide the highest data transfer rate (depending on the type of active equipment used, the transfer rate can be tens of gigabytes and even terabytes per second). The following article is devoted to the study of optical communication systems.

Keywords: optical fiber, telecommunication, transmission system, amplifier, information security, intelligent data network.

DOI Number: 10.14704/nq.2022.20.5.NQ22579 **NeuroQuantology 2022; 20(5):2189-2195**

INTRODUCTION

Quartz glass, which is the carrier medium of FOCL, in addition to unique transmission characteristics, has another valuable property - low losses and insensitivity to electromagnetic fields. This sets it apart from conventional copper cable systems.

This information transmission system is usually used in the construction of working facilities as external highways that unite disparate structures or buildings, as well as multi-story buildings. It can also be used as an internal carrier of a structured cabling system (SCS), however, complete SCS made entirely of fiber are less common due to the high cost of building optical communication lines.

The use of FOCL allows you to locally combine workplaces, provide high-speed Internet downloads simultaneously on all machines, high-quality telephone communications and television reception.

Advantages of FOCL

With proper design of the future system (this stage involves the solution of architectural issues, as well as the choice of suitable equipment and methods for connecting carrier cables) and professional installation, the use of fiber optic lines provides a number of significant advantages:

High throughput due to high carrier frequency. The potential of one optical fiber is several terabits of information per 1 second.

Fiber optic cable has a low noise level, which has a positive effect on its bandwidth and the ability to transmit signals of various modulations.

*e*ISSN 1303-5150

Fire safety (fire resistance). Unlike other communication systems, FOCL can be used without any restrictions in high-risk enterprises, in particular in petrochemical industries, due to the absence of sparking.

Due to the low attenuation of the light signal, optical systems can unite working areas at considerable distances (more than 100 km) without the use of additional repeaters (amplifiers).

Information Security. Fiber-optic communication provides reliable protection against unauthorized access and interception of confidential information. This ability of optics is explained by the absence of radiation in the radio range, as well as high sensitivity to vibrations. In the event of eavesdropping attempts, the built-in monitoring system can disable the channel and warn of a suspected hack. That is why FOCL is actively used by modern banks, research centers, law enforcement organizations and other structures that work with classified information.

High reliability and noise immunity of the system. The fiber, being a dielectric conductor, is not sensitive to electromagnetic radiation, is not afraid of oxidation and moisture.

MATERIALS AND METHODS

Profitability. Despite the fact that the creation of optical systems, due to their complexity, is more expensive than traditional SCS, in general, their owner receives real economic benefits. Optical fiber, which is made of quartz, costs about 2 times cheaper than copper cable; additionally, when building extensive systems, you can save on amplifiers. If, when using a copper pair, repeaters need to be installed every few kilometers, then in FOCL this distance is at least 100 km. At the same time, the speed, reliability and durability of traditional SCS are significantly inferior to optics.

The service life of fiber-optic lines is half a quarter of a century. After 25 years of continuous use, signal attenuation increases in the carrier system.

If we compare copper and optical cables, then with the same bandwidth, the second one will weigh about 4 times less, and its volume, even when using protective sheaths, will be several times less than that of copper.

Perspectives. The use of fiber-optic communication lines makes it easy to increase the computing capabilities of local networks by installing faster active equipment, and without replacing communications.

Scope of FOCL

As mentioned above, fiber optic cables (FOC) are used to transmit signals around (between) buildings and inside objects. When building external communication highways, preference is given to optical cables, and inside buildings (internal subsystems), traditional twisted pair is used along with them. Thus, FOCs are distinguished for external (outdoor cables) and internal (indoor cables) laying.

Connecting cables belong to a separate type: indoors they are used as connecting cords and horizontal wiring communications - to equip individual workplaces, and outside - to connect buildings.

Installation of a fiber-optic cable is carried out using special tools and devices.

FOCL connection technologies

The length of FOCL communication trunks can reach hundreds of kilometers (for example, when building communications between cities), while the standard length of optical fibers is several kilometers (also because working with too long lengths is very inconvenient in some cases). Thus, when constructing a route, it is necessary to solve the problem of splicing individual fibers.

There are two types of connections: detachable and one-piece. In the first case, optical connectors are used for the connection (this is associated with additional financial costs, and, in addition, with a large number of intermediate detachable connections, optical losses increase).

For the permanent connection of local sections (assembly of routes), mechanical connectors, adhesive splicing and welding of fibers are used. In the latter case, devices for welding optical fibers are used. Preference is given to one or another method, taking into account the purpose and conditions for the use of optics.

Splicing of optical fibers

The most common today is the technology of fiber welding.

The highest quality connection with minimal losses ensures the welding of fibers. This method is used to create high-speed FOCLs. During welding, the ends of the light guide are melted; for this, a gas burner, electric charge or laser radiation can be used as a source of thermal energy.

Each of the methods has its own advantages. Laser welding, due to the absence of impurities, allows you to get the cleanest joints. For durable welding of multimode fibers, as a rule, gas torches are used. The most common is electric welding, which provides high speed and quality of work. The melting time of different types of optical fibers is different.

For welding, special tools and expensive welding equipment are used - automatic or semi-automatic. Modern welding machines allow you to control the quality of welding, as well as test joints for tension. Advanced models are equipped with programs that allow you to optimize the welding process for a specific type of fiber.

After splicing, the junction is protected by tightly fitting tubes, which provide additional mechanical protection.

Another method of splicing fiber optic elements into a single fiber optic line is a mechanical connection. This method provides a lower purity of the connection than welding, however, the signal attenuation in this case is still less than when using optical connectors.

The advantage of this method over the others is that simple devices (for example, a mounting table) are used for work, which allow working in hard-to-reach places or inside small structures.

Mechanical splicing involves the use of special connectors - the so-called splices. There are several varieties of mechanical connectors, which are an elongated structure with a channel for entering and fixing spliced optical fibers. The fixation itself is provided with the help of the latches provided for by the design. After connection, the splices are additionally protected by couplings or boxes.

Mechanical connectors can be used repeatedly. In particular, they are used during repair or restoration work on the line.

FOCL: types of optical fibers

Optical fibers used to build FOCLs differ in the material of manufacture and in the mode structure of light. In terms of material, there are all-glass fibers (with a glass core and a glass optical cladding), all-plastic fibers (with a plastic core and a sheath) and combined models (with a glass core and a plastic sheath). The best throughput is provided by glass fibers, a cheaper plastic version is used if the requirements for attenuation and throughput parameters are not critical.

According to the type of paths that light travels in the core of the fiber, single- and multi-mode fibers are distinguished (in the first case, one beam of light propagates, in the second - several: tens, hundreds, and even thousands).

Single-mode fibers (SM) are characterized by a small core diameter, through which only one beam of light can pass.

Multimode fibers (MM) have a large core diameter and can be stepped or gradient. In the first case, the light beams (modes) diverge along different trajectories and therefore arrive at the end of the fiber at different times. With a gradient profile, the time delays of the various beams almost completely disappear, and the modes go smoothly due to the change in the speed of light propagation along the undulating spirals.

All modern fiber optic cables (both single- and multimode), which are used to create data transmission lines, have the same outer diameter - 125 microns. The thickness of the primary protective buffer coating is 250 µm. The thickness of the secondary buffer coating is 900 µm (used to protect patch cords and internal cables). The sheath of multi-fiber cables is painted in different colors for ease of use (for each fiber).

Basic principle of fiber optics

The principle of fiber optics is to use light pulses to transmit information from one point to another through a special cable. The transmitted information is essentially digital information generated by telephone systems, cable television companies and computer systems.

An optical fiber is a dielectric cylindrical waveguide made from materials, usually silicon dioxide. The core of the waveguide has a refractive index slightly higher than that of the outer medium (cladding), so that light pulses are directed along the fiber axis by total internal reflection.

Fiber optic systems consist of:from a transmitter for converting an electrical signal into an optical signal for transmission over a cable containing several bundles of optical fibers;

amplifiers to increase signal power;

receiver to reconvert the received optical signal back to the original transmitted electrical signal.

Future trends in fiber technology

Fiber optic technology is, of course, a promising data transmission. The use of new fiber optic technologies will be driven by the development and increase in demand for information transmission. It is expected to continue into the future as new and more advanced communications technologies develop.

The following are some of the anticipated future trends in fiber optic technology all transmission networks are optical.

Full fiber optic data transmission is provided. In such networks, all signals will be processed in the optical domain, without any electrical manipulation.

Currently, signal processing and switching takes place in the electrical domain, optical signals must first be converted into an electrical signal before they can be processed and sent to their destination. After processing and routing, the signals are then re-converted into optical signals that are transmitted over long distances to their destination. This optical to electrical conversion, and vice versa, introduces additional network delay and is thus a limitation for achieving very high data rates.

Another advantage of all optical networks is that there will be no need to replace electronics as data rates increase, since all signal processing and routing takes place in the optical domain. However, before this becomes a reality, the problems of optical routing and wavelength switching must be solved. Research is currently underway to find an effective solution to these problems.

Terabit networks

Wavelength division multiplexing helps to achieve speeds of several terabits. The global demand for increased bandwidth has led to an interest in the development of multi-terabit networks. The researchers are looking at achieving even higher throughput at 100Tbps. As the cost of fiber optic components continues to decrease, much more bandwidth may be available in the future.

Intelligent Data Network

At present, traditional optical networks are unable to adapt to the rapid growth of online data services due to the unpredictability of dynamic bandwidth allocation. Traditional optical networks rely mainly on manual network connection setup, which is time-consuming and unable to fully adapt to the requirements of today's network.

The intelligent optical network is the future development trend and will have the following applications:

traffic design,dynamic allocation of resource routes,special control protocols for network management,scalable signaling capabilities,throughput on demand,wavelength lease.

It will take some time before the intelligent optical network can be applied at all levels of the network;

Ultra-long distance transmission

In the field of ultra-long-haul optical transmission, research is subject to restrictions imposed due to the imperfection of the transmission medium. The dispersion effect has prompted researchers to explore the potential benefits of soliton propagation (solitary wave). A deeper understanding of the interactions between an electromagnetic light wave and the transmission medium is necessary in order to proceed to the creation of an infrastructure with the most favorable conditions for the propagation of a light pulse.

Improvements in laser technology

MATERIALS AND METHODS

Another future trend will be the expansion of existing semiconductor lasers to a wider range of generation wavelengths. Short wavelength lasers with very high output power are of interest in some high density optical applications.

Currently, laser sources are available that have a spectral shape capable of compensating for chromatic dispersion. Single-mode tunable lasers are of great importance for future coherent optical systems. These tunable lasers operate in a single longitudinal mode that can be tuned to a range of different frequencies.

Neural network laser nodes

A laser neural network is an effective option for implementing optical network nodes.

It is assumed that a specialized hardware configuration operating in the optical domain and the use of ultra-fast photonic sections will further increase the throughput and speed of telecommunication networks.

As networks become more complex in the future, the use of laser neural nodes could be an effective solution.

Polymer optical fibers

Polymer optical fibers offer many advantages over other data transmission solutions such as copper cables, wireless communications systems, and fiberglass.

Compared to glass, polymer optical fibers provide easier and less expensive signal processing, and are more flexible for detachable connections. The use of polymer optical fibers as a transmission medium for aircraft is currently being studied by various research groups due to their advantages.

CONCLUSION

In addition, in the future, polymer optical fibers are likely to replace copper cables for connection in the junction box of the telecommunications company and the end user being served.

Improvements in optical transmitter/receiver technology

In fiber optic technology, it is important to achieve high transmission quality even for signals with distorted waveforms and low signal-to-noise ratio during transmission. Research is currently underway to develop optical transceivers using new and advanced modulation technology, with excellent chromatic dispersion and signal-to-noise ratio tolerance, which will be suitable for ultra-long range communication systems.

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*e*ISSN 1303-5150