Development of Architecture and Structural Diagram of Regional Optical-Fiber Communication Lines

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ABSTRACT

The article discusses the advantages, scope, block diagrams of fiber optic communication lines of regional telecommunication communication networks, also talks about the capabilities of fiber optic communication lines and the high quality of information transmission over fiber optic communication lines and talks about the information security of fiber optic communication lines

Keywords:

Introduction

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).
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-storey 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.[1-3]

Main Part

Fiber-optic communication provides reliable protection against unauthorized access and interception of confidential information. This ability of optics is due to 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.[5-7]
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.
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 a 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 a copper and an optical cable, 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.

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.

The length of FOCL communication backbones 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).

A schematic block diagram of a fiber-optic communication system is shown in fig. 1. Let's make an enlarged approximate calculation of several options for the optical cable used as an inter-office connecting line of the GTS.

Rice. 1. Block diagram of the interstation fiber-optic connecting line of the GTS.

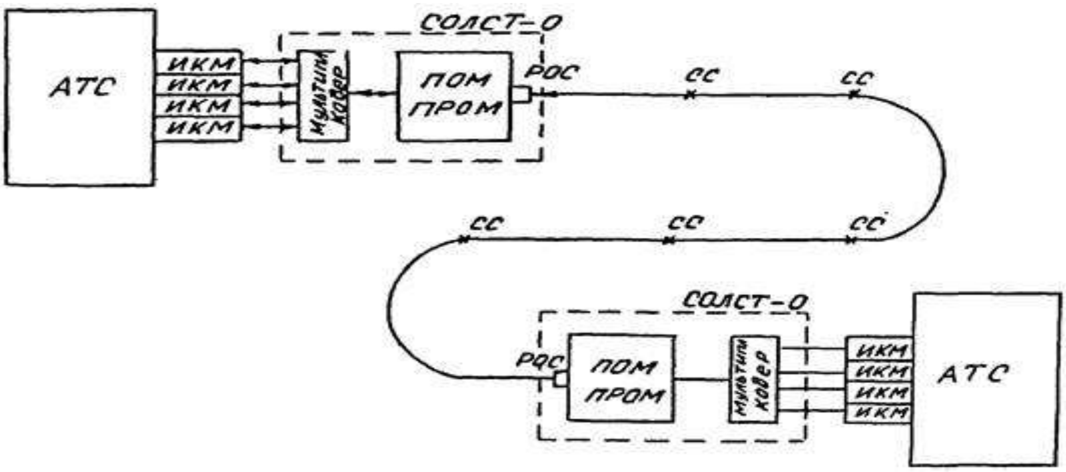
(where: SOLST - terminal equipment rack of a linear light guide path;

ROS - detachable optical connector;

SS - welded joint) divide the possible length of the FOCL without regeneration with the following given parameters:

1. power level at the output of the transmitting device Rp - (+10 dBm);

2. power level at the input of the receiving device Rp - (-50 dBm);



Task: Oprah

Rice. 1. Block diagram of the interoffice fiber optic trunk PBX

3. λ - absorption coefficient in optical fiber

1.3 - 1.5 dBm

at λ = 1.3 μm and 0.85 - 3.0 dBm

at λ = 0.85 μm

4. ss - losses on the welded connector

ss = 0.3 dB.

5. grew - losses on detachable optical connectors

dew = 1.0 dB.

6. Building lengths of the fiber-optic cable - l km = 2 km; L = nl

7. Number of telephone channels 120 (IKM-120)

8. The energy reserve necessary to compensate for the deterioration in the characteristics of the elements due to their aging st (approximately 6 dB), unaccounted for destabilizing factors df (power supply, temperature, radiation, etc. - 4 dB). Usually the energy reserve

E.Z = st + df ≈ 10 dB

In general, the length of the regeneration section is determined by the following energy expression

losses in the fiber energy potential

$$\hat{\alpha}_{\lambda} L + \alpha_{cc} \cdot \frac{L}{l} + 2\alpha_{poc} \le P_{пом} - P_{пром} - \varepsilon$$

$$L \le \frac{P_{пом} - P_{пром} - \varepsilon - 2\alpha_{poc}}{\hat{\alpha}_{\lambda} + \alpha_{cc} \cdot \frac{1}{l}}$$

для λ = 0,85 мкм

$$L_{0,85} = \frac{10 - (-50) - 10 - 2}{3 + \frac{0,3}{2}} \le 12,9\,км$$

$$L_{1,3} = \frac{10 - (-50) - 10 - 2}{1,5 - \frac{0,3}{2}} \le 29,0\,км$$

для λ = 1,3

For coaxial cables, the length of the regeneration section is within 2 ÷ 5 km.

Since the length of the regeneration section is affected not only by the attenuation of the optical signal in the fiber, but also by the frequency characteristics, i.e. broadening (dyspepsia) of the transmitted signal due to intermodal dispersion and due to the distance on the material □p, then the next step in the calculation is to determine the length L□ - critical, when the transmitted signal is still understandable at the receiving end. For IKM-120, the frequency of the clock package is Ft = 8.448 MHz; for PCM modulation Ft = B - the rate of transmitted information B = 8.448 Mbps.

It is known that for gradient fibers a[ ] is usually a few nanoseconds and even fractions per kilometer. The criterion for estimating the length of the communication line is the expression

Assuming a = 1 ns/km

Thus, using a gradient optical fiber at a wavelength of λ = 1.3 μm, it is possible to provide communication without regeneration over a distance of about 29 km. If we use a fiber with a stepped refractive index profile, for which a = 30 ÷ 70 ns/km, then the signal in the received optical signal will be incomprehensible due to dispersion.

Obviously, for IKM-480, for which the data transfer rate is B = 34 Mbps, the length of the regeneration section due to dispersion cannot be more than 7.5 km at λ = 1.3 μm, and for λ = 0.85 μm L □ 3 km with the same fiber attenuation coefficients. For digital transmission of a television signal, a speed of B = 140 Mbps is required, so it is necessary to choose a single-mode fiber-optic cable, for which the dispersion can reach 0.05 - 0.1 ns/km. Components that provide such high data transfer rates are expensive.

To transmit a TV signal, pulse-frequency (PFM) or pulse-phase (PPM) modulation is currently used, in which case B \u003d 10 Mbit / s, and therefore a multimode fiber with a gradient refractive index profile can be used.

For the organization of a LAN of the EtherNet type, the data transfer rate is 10 Mbps, and for ArcNet - 2 Mbps. As a rule, most networks used in practice have speeds of 10 Mbps or less.

In the last two examples, the length of the regeneration section is limited by the energy potential, which is usually 20 ÷ 40 dB.

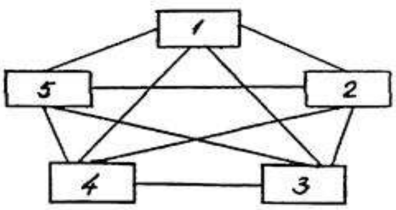
In practice, when the length of the cable laying is known and there are specific construction lengths l of the incoming cable with specific attenuation coefficients, it would be more correct to determine the loss in the fiber as follows:

This expression indicates the importance of observing the technological mode of cable selection, welding and accuracy when working with detachable connectors. It is not uncommon for ss to reach 1.5 dB or more. The presence of one dust grain with a size of 5 μm on the surface of a multimode fiber causes an increase in attenuation in the path by 0.1 dB, and undertightening of the gap between the joined fibers by only 20 μm leads to an increase in connector losses up to 2–3 dB. A large number of sharp bends leads to intermodal redistribution, and this increases the intermodal dispersion; eventually Lcritical decreases.

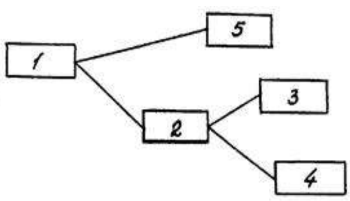
Block diagrams of fiber-optic networks.

Depending on the structural organization of networks for various purposes, whether it be: LAN or systems for collecting and transmitting information, television or telephone, required for fiber-optic lines; communication requirements do not have significant differences. However, significant differences are presented to the final converting devices, in addition, intermediate regenerators are introduced. For this reason, we will consider the most common structural organizations in practice - network topologies. According to topological features, networks are divided into the following types: arbitrary, "tree" type (hierarchical structure), ring (or chain) configuration, "common bus" configuration, " star".

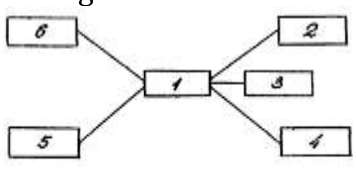
The simplest method of building a network is the direct connection of all devices that must interact with each other via a device-to-device communication line (Fig. 2). Each communication line can use different transmissions and different interfaces, the choice of which depends on the structure and characteristics of the connected devices (1, 2, 3, 4, 5 - Fig. 2). This way of connecting devices is quite satisfactory for networks where the number of connections is limited. The main advantages of this method lies in the need to connect each to each at a simple physical level, where no complex software implementation is required, in the simplicity of the interface structure, and there is no need to compact information in communication channels. The disadvantages of this structure are: the high cost of the data transmission system; a large number of channels used (each subscriber has as many communication channels as he wants to connect with subscribers); a large length of communication channels between the most remote subscribers. Such a network refers to multi-node networks that provide a variety of route options.



Rice. 2. Network of arbitrary configuration



Rice. 3. Hierarchical network "tree"



Rice. 4. Star network

Another common way to connect a network with the largest number of nodes is a hierarchical "tree" configuration (Fig. 3.)

The tree network is usually used in cable television systems, systems for collecting and transmitting information from technological facilities, and is less commonly used when creating a LAN. These distribution systems must be from the switching node (1, Fig. 3) or information source through a constantly branching structure with the Nth terminal device and vice versa. The advantages of this method are that the high speed of interaction between subscribers, the ability to choose the optimal connection path. The disadvantages lie in the complex software. Typically, this connection method is used with a small number of subscribers.

In star configuration networks (Fig. 4), end devices are connected to each other through an optical power splitter of the star type or connected to a switching node that performs the necessary distribution of messages, or in EtherNet and ArcNet LAN networks through active or passive " hubs". Advantages: simplicity of the logical and software structure, ease of connecting two subscribers. Disadvantage: low efficiency of using communication channels, high cable consumption.

Conclusion

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 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.

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.

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