Loss Mechanisms of Optical Cables Used in Communication Lines

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ABSTRACT

In this work, the mechanisms of optical loss in fiber were considered. The mechanisms of special infrared (IR) and ultraviolet (UV) absorption were considered, and the technical characteristics of optical fibers used in communication lines were considered. It analyzed mainly the types, properties of optical fiber, the predominance of fiber optic cable and the losses in fiber optic cables used in communication lines. The results of measuring the signal attenuation in the line of the users using the optical communication line, the signal absorption depending on their line distance and the number of connections in the line were obtained using a reflectometer device.

Keywords: Losses in optical fiber, germanium dioxide, quartz glass, loss mechanisms, infrared and violet absorption. Optical Fiber, One-modal, multi-modal, Quartz, multi-component glass, polymer, losses in the communication line, Reflectometer.

Introduction.

The 21st century is considered the age of information technologies, and it is gaining great importance in achieving unprecedented achievements in many fields. Optical communication lines have an important place in the development of information technologies. It is known that optical fibers are made of glass or plastic. Light is transmitted from one end to the other along the middle of the fiber and a signal is given. It is possible to transmit several terabits of data per second along one optical fiber. Low attenuation of light signals in optical fiber, the width of the data transfer range, is one of the most important advantages of fiber optical communication over copper and other information transmission media. [1]

Since more than one mode of radiation can usually be scattered in a fiber, the change in radiation power during propagation through the fiber is given by the sum of similar expressions for each mode:

$$P = \sum P_i \times exp(-a_i x), \qquad (1)$$

here is the radiation intensity of the i - th fashion at the point of entry of the *Pi*-fiber (at the beginning of the fiber, attenuation coefficient for a_i-*i*-th fashion, and *P* is the light intensity at a point at a distance x from it. [2].

Each fashion has a different area distribution and therefore optical losses are different in them, because for each fashion, the capacities of the scattering of power along the core and along the Shell will be different (Goos-Genchen shift). The resulting Equation (1) is much more complex, because its Pi coefficient in each Hand depends on the nature of the excitation of the fiber and the determination of a_i - optical losses.

The beam fibers used in telecommunication lines are mainly made of silicon glass and are marked with additives that increase the core breaking performance. The most commonly used additive in this is germanium dioxide.

The addition of germanium dioxide increases the refractive index of quartz glass in the visible and infrared area of the spectrum, and this change is determined by the following formula:

$$\Delta n = 1.443 \times 10^{-3} C, \quad (2)$$

here C – mol % da GeO_2 konsentratsiyasi.

In practice, the relative difference between the core and shell refractive indices -Δ magnitude is often used:

$$\Delta = \Delta n / n, \quad (3)$$

where n is the shell breaking indicator.

Optical losses in Beam fibers are caused by the absorption and scattering of radiation propagating along them. In turn, losses are allocated to excessive losses that occur due to the imperfection of the technology of production of special and fiber, which is determined by fundamental mechanisms. No matter how much the fiber production process is improved, the fundamental loss remains anyway. The typical loss spectrum of quartz glass is shown in Figure 1. shows that the lowest optical losses correspond to the 1.55 and 1.31 μm region of the spectrum, this corresponds to the first and second transparent windows of telecommunication lines [3]. We consider the contribution of different loss mechanisms to the total optical loss.

First, let's look at specific infrared (IR) and ultraviolet (UV) absorption. The vibrations of the atoms in the quartz glass crystal lattice cause absorption within the IQ limit (Figure 1). The maximum absorption range associated with SiO garden vibrations lies in the 9-21 micron range of the spectrum. The multi-phonon absorption limit of SiO_2 is in the near-IR range and is described by the following empirical formula:

$$a_{ir} = 3{,}4 \times 10^{11} exp(-38{,}9E)[db/km] \quad (4)$$

where E is the energy in eV.

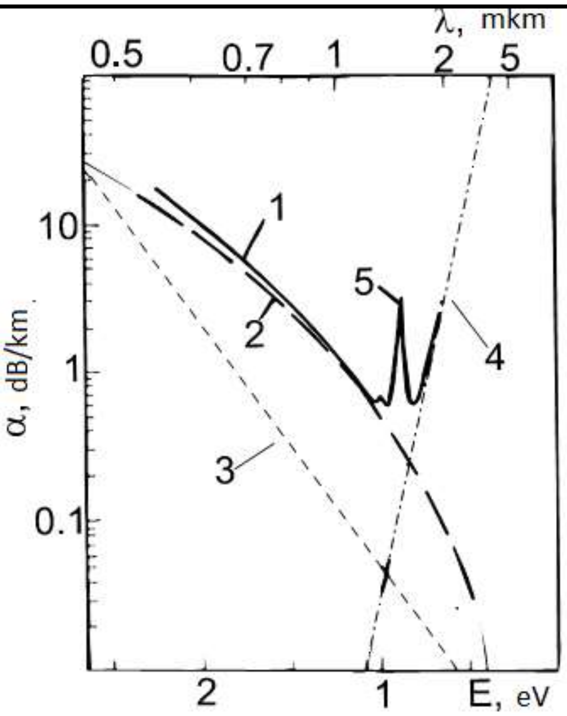


Figure 1. Splitting optical losses in optical fibers into components:

In this: 1-optical loss in optical fibers (11% GeO_2), losses as a result of 2-Rayley scattering, losses at the border of Zone 3, losses at the border of 4 - phonon absorption, losses as a result of the absorption of groups 5-OH [2].

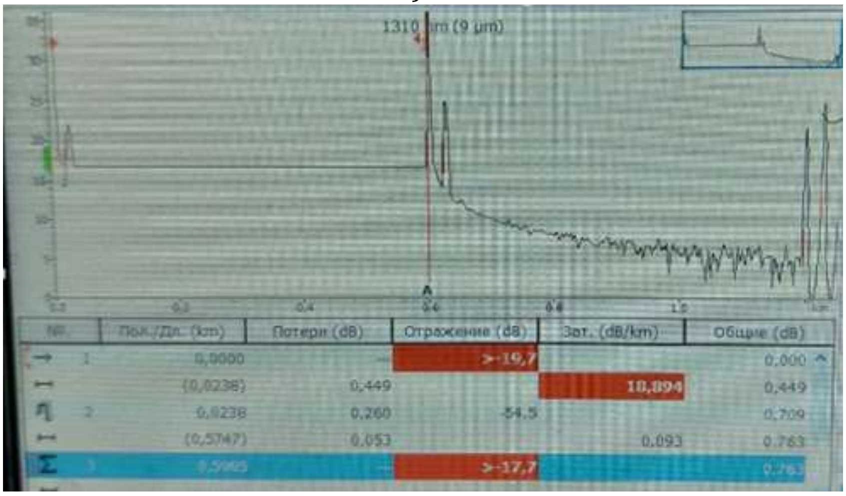
The full absorption limit of GeO_2 is shifted to longer wavelengths by about 700 cm-1 compared to the absorption limit of SiO_2. Therefore, if the fiber content $xGeO_2$ - (1-x) S_iO_2 has a glass core, its IR absorption limit will also be shifted towards long wavelengths:

$$a_{ir} = (3{,}4 - 3{,}3x) \times 10^{11} exp\{-38{,}9E\}[dB/km] \quad (6)$$

THE MAIN PART.

Technical measurements on this scientific research work were carried out on optical communication lines of subscribers of JSC Uzbektelecom in the urban area of Urgench, Khorezm region the causes of losses were identified and analyzed. The mechanisms for the loss of cables in optical communication lines were carried out through a reflectometer produced by the EXFO firm (Figure 1) and using the Billing system of the AK “Uzbektelecom”. Figure 2 shows the results obtained using the Billing system.

a)



b)

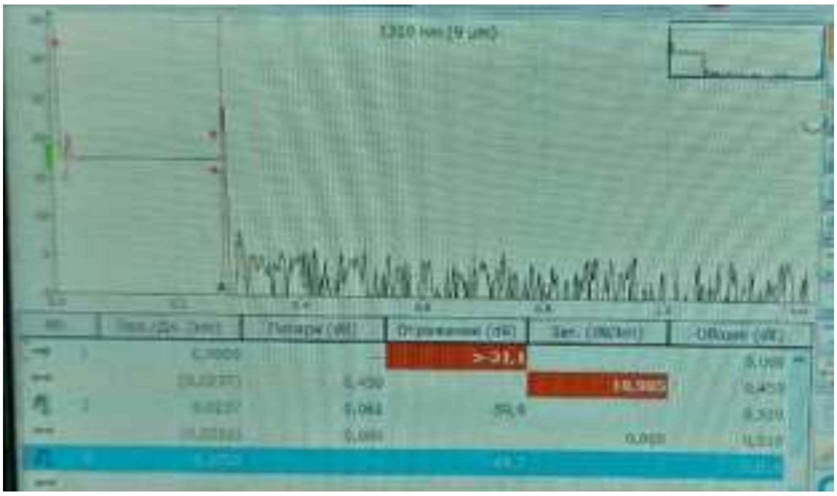


Figure 2. (a, b) results of losses in the optical communication line obtained using a reflectometer

Серийный номер	ZTEGC4EDD4F5 (ONT ищется по параметру 'ONT Pon Serial')
Версия	V7.0
Тип	ZTE-F660 F660V7.0
Версия ПО	
RSSI (dBm)	
Rx / Tx power (dBm)	-17.644 / 2.234
Расстояние (м)	5137
IP-адрес	
Маска подсети	
Шлюз	
Предпочитаемый DNS	Акти
Альтернативный DNS	Чтобы

a)

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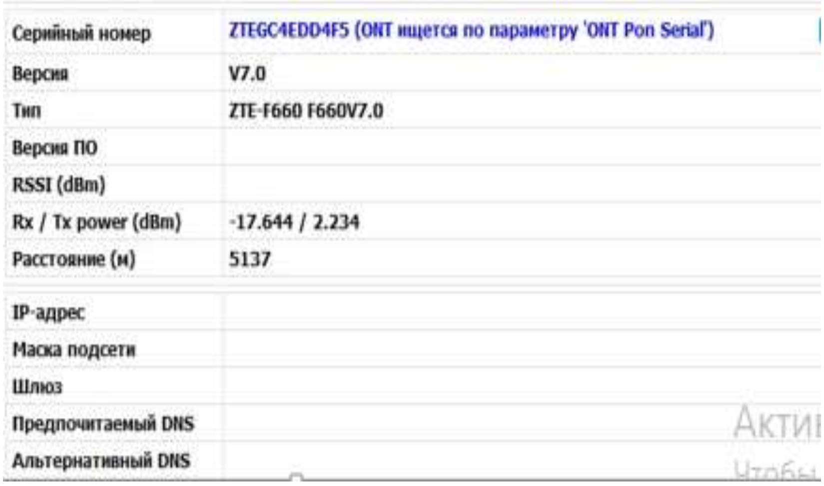

b)

Figure 3. (a, b) determination of losses in the optical communication line through the Billing system

The results obtained using the studies carried out in Table 1 are summarized. We conducted scientific research on losses, cable type, line length, number of inter-device connections and degrees of bending in subscriber lines connected to 4 optical communication lines. Connections in the optical communication line are made by welding, this process causes losses in the optical communication line, that is, the optical fiber is perfectly cleaned of protective means during welding, it requires high precision in the process of straight cutting and welding. Otherwise, losses from -0.2 to -0.5 dB occur during welding. The devices are connected through a fiber connector. It usually has losses up to -0.1 dB. If the process of welding the optical fiber to the connector is performed incorrectly, signal losses from -0.3 to -1 will occur. Losses do not depend on the length of the optical fiber, but are caused by defects in the fiber optic connection line, at the connection points with devices, and in the process of laying the optical cable. For example: if the angle of the fiber laid in the optical communication line exceeds 45°, it causes losses. If the loss in the optical communication line exceeds -30 dB, it will cause several problems in the optical communication line.

Table 1. Results obtained through measurements.

T/r	Dimensions	1- line	2- line	3- line	4- line
1	Line length (m)	5092	5137	600	300
2	Losses (dB)	-18.1	-17.6	-17.7	-17.7
3	Optical cable type	Gjyxch2B6a2	Gjyxch2B6a 2	Gjyxch2B6a 2	Gjyxch2B6a 2
4	The degree of maximum bending of the fiber	45° up to	45° up to	45° up to	45° up to
5	Number of connections between devices	6	6	4	4
6	Number of connections	2	2	-	-

CONCLUSION

This absorption contributes significantly to the total spectrum losses only at wavelengths above 1.85 μm (more than 1 dB/km) and is not significant in telecommunication transparency windows. This absorption contributes significantly to total spectrum losses only at wavelengths above 1.85 microns (greater than 1 dB/km) and is not significant in telecommunication transparency windows. Losses vary depending on the types of optical fibers used in optical communication lines. In the field of telecommunications, optical fibers with wavelengths of 1.3 μm are widely used, and their losses are in the range of 0.4-1.0 dB/km. If losses greater than the above-mentioned losses are observed, then interruptions occur in the optical communication line, and in this case, the usable data exchange in the optical communication line stops.

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