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IMPLEMENTATION OF ATTENUATION IN FIBER OPTICAL DEVICES

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Abstract: in the proposed work the implementation of different influencing factor of attenuation in fiber optical devices has been presented. Absorption of optical energy by tiny impurities in fibers such is iron, copper, or cobalt. Attenuation is a measure of the loss of signal strength or light power that occurs as light pulses propagate through a run of multimode or single-mode fiber. Measurements are typically defined in terms of decibels or dB/km. The different size fibers have different optical loss dB/km values. Fiber loss depends heavily on the operating wavelength. It has been simulated with respect to distance, joints, and connectors. In the research work the attenuation in different cases is calculated. Along with this the comparative analysis of attenuation is also provided in different scenarios. In the future the research work would be beneficial.

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Keywords: Optical Devices, Fiber optic, Attenuation, Wavelength, Optical Links, Total Attenuation (TA)

[1] INTRODUCTION

System design has centered on the subscriber-loop plant and long-haul communications. The
Subscriber loop plant is the part of a system that connects a subscriber to the nearby switching center. Cable TV is an example of subscriber loop plant. Limited work has been done on short distance applications and some military communication systems. Initially, central office truncation required multimode optical fibers with moderate to extreme performance. Fiber performance depends on the amount of loss occur and signal distortion introduced in the fiber when it is operating at a specific wavelength. Long-haul systems require single mode optical fibers with very high speed and performance. Single mode fibers tend to have lower loss and produce less signal distortion. In contrast, short-distance and military systems tend to use multimode fiber technology. Examples of short-distance systems include process control and local area networks (LANs). Short-distance communication and military systems have many connections. The larger fiber core and high numerical aperture of multimode fibers tend to reduce losses at these connections.

[2]OPTICAL FIBER TYPES

Different types of optical fibers are applied in telecommunications, computer data communication networks and other applications. Fiber Optic waveguides can be divided into various categories considering:

a) Structure (cylindrical, birefringence, planar, strip)
b) Number of modes (single mode or multimode fiber)
c) The refractive index profile (step index or graded index fiber)
d) Material (glass, plastic, semiconductor)
e) Dispersion (Dispersion shifted fiber, Non zero dispersion shifted fiber, Dispersion flattend fiber)
f) Signal processing ability (passive component- data transmission, active component-amplifier)
g) Polarization (classic, polarization maintaining/preserving fibers)

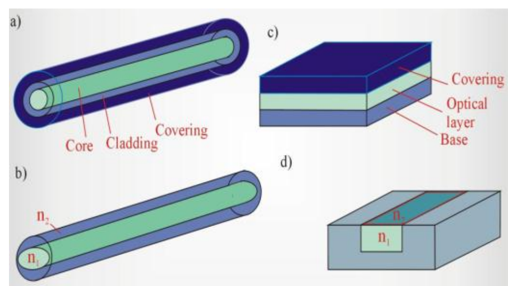

Fig 1 Different types of optical waveguide

Cylindrical Waveguide:

It consists of dielectric core, most often glass, cylindrically shaped in that light propagates as shown in figure 1.3(a). The core is bounded by cylindrical layer of dielectric material of lower refraction index than core, called cladding. Generally refractive index difference is around $n_1- n_2 = 0.005$ whereas n_1 indicate core refractive index and n_2 indicate cladding refractive index. The outside jacket serves a protective role.

Planar waveguide:

It is a rectangular block consisting of three layers: base, light channel layer and coating. The base layer and the coating layer consist of lower index of refraction than optical layer which work as a channel for light as shown in figure 1.3(c).

Considering the number of propagation mode, we can divide optical fibers into two types that are single mode fiber and multimode fibers. The mode is one of the permitted structures of the EM field propagating in the optical fiber.

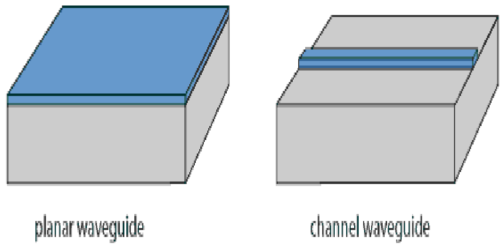

Fig 2 Planar waveguide

Single mode and Multimode optical fibers

Single mode fibers have small core diameter to permit single mode propagation, the cladding diameter must be at least ten times the core diameter to avoid losses from evanescent field. Therefore with a coating and buffer jacket to provide protection and strength, single mode fibers have overall diameter to multimode fibers. Single mode fiber being fabricated from doped silica to produce high quality, both medium and long haul, wideband transmission fiber suitable for range of telecommunication application.

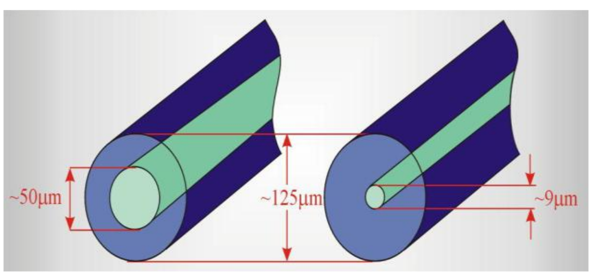

Fig 3 Dimensions of the multimode fiber (a) and single mode fiber (b)

Step index and Graded index fibers:

The optical fibers discussed here are characterized by the constant core refractive index that have a discontinuity at the core and cladding interface and are known as the step-index fibers. In order to reduce the effect of the intermodal dispersion, the refraction index of the core varies continuously in the direction perpendicular to fiber axis. This types of fiber show the parabolic refractive index profile that depends on a radial distance(r) from the fiber axis and $n_0 >> n_r$.

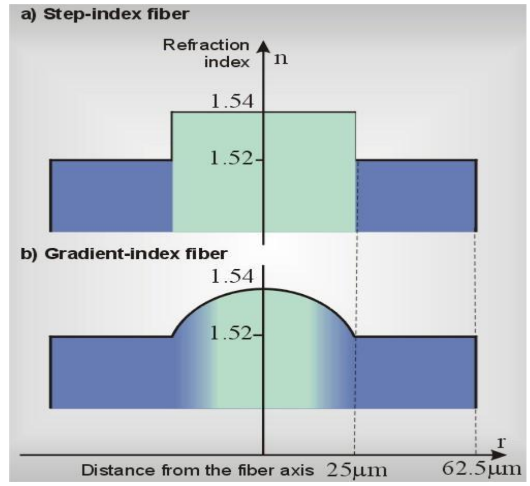

Fig 4 Refraction index profile in the step-index fiber and the graded-index fiber

In these types of optical fibers the refractive index variation progressively decreasing from the core to the cladding. The refractive index of the core is the high in the center of the core and gradually decreases with radial distance approaching the core-cladding interface. Such type a profile refractive index is obtained by applying layer structure of the core with decreasing refractive index from fiber axis to core cladding surface. The geometrical light signal path in such fibers follow a curve path as it is not takes place in the case of the step-index fibers, but in it is sinusoidal, helical or axial.

Polarization-maintaining (PM) optical fibers:

In some applications, constant polarization of light in an optical fiber becomes essential to maintained. Such type of polarization occur in fiber interferometers, sensors, fiber laser, external fiber modulators, coherent light transmission and in integrated optical circuits coupling. In addition, in all optical fibers to smaller or higher extent, attenuation or loss depends on polarization of signal and deteriorates signal propagation in optical fiber. In a perfect optical fiber, there is no eminent optical axis and core and cladding are made of isotropic material, therefore there is no birefringence.

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Dispersion Shifted-Single Mode Fiber (DS-SMF):

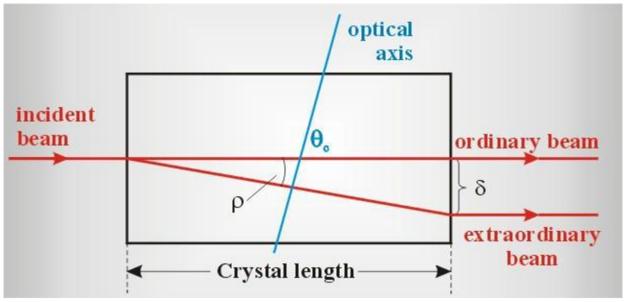

Fig 5 Uniaxial birefringence crystal

These are characterized by gradient profile of refractive index and strongly negative dispersion in II transmission window that is below 20ps /nm km and zero dispersion for 1550 nm wavelength in III window. Their main application is a long distance transmission of signal in single channel III window. They are not appropriate for multichannel transmission, for the reason that the lack of dispersion causes cross talks due to other nonlinear effect. Thus, in order to reduce nonlinear effect of dispersion and at the same time exclude four wave mixing. Dispersion shifted fiber has recently been subjected to the standardized recommendation ITU-T G.653.

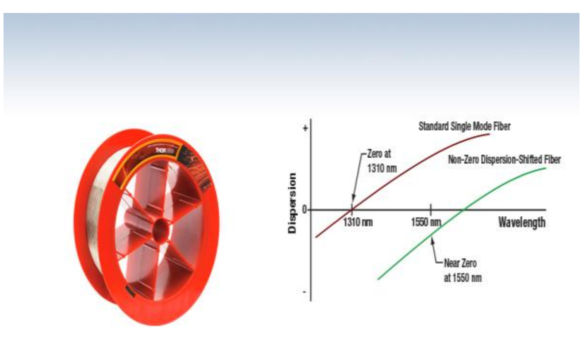

Fig 6 Dispersion Shifted-Single Mode Fiber

[2]OBJECTIVE

The research is based on performance influencing factors of fiber optics. This factor is attenuation. This research considers the attenuation due to increase in distance, number of joints and number of connectors. The objectives of research are as follow:

1. To study the need, scope and working of fiber optics
2. To investigate the performance influencing factors of fiber optical devices.
3. To study the existing researches related to fiber optics.
4. To analyze the influencing factors in case of attenuation.
5. To simulate the attenuation with respect to distance, number of joints, number of connections.
6. To perform comparative analysis of impact on attenuation considering above mentioned factors.

[3] PROBEM STATEMENT

The attenuation in fiber optics has been influenced by increase in distance, number of joints and number of connectors. Several problems are faced due to attenuation in fiber optics. There is need of repeater in order to regenerate the signals. However there are several other factors that results in attenuation but our research focus on three factors

1. Distance
2. Number of joints
3. Number of connectors

However there have been several researches regarding fiber optic performance. But the simulation of attenuation in different circumstances is the major concern of this research.

Usually performance and cost get increase when wavelength increases. Multimode and single-mode fibers are using various fiber types or sizes. For example, single-mode fiber uses 9/125 um and multimode uses 62.5/125 or 50/125. The different size fibers have different optical loss dB/km values. Fiber loss is depending heavily on operating wavelength. Practical fibers are having minimum loss at 1550 nm and the highest loss at 780 nm with all physical fiber sizes.

[4] IMPLEMENTATION WORK

Generally, performance and cost increase as wavelength increases. Multimode and single-mode fibers use different fiber types or sizes. For example,

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Table 1 – For Wavelength 1310nm

	Attenuation/ Km (dB/Km)	**Attenuation/optical connector (dB)**	**Attenuation/joint (dB)**	
Min	0.3	0.4	0.02	Best Conditions
Average	0.38	0.6	0.1	Normal
Max	0.5	1	0.2	Worst situation

Table 2 – For Wavelength 1550nm

	Attenuation/ Km (dB/Km)	**Attenuation/optical connector (dB)**	**Attenuation/joint (dB)**	
Min	0.17	0.2	0.01	Best Conditions
Average	0.22	0.35	0.05	Normal
Max	0.4	0.7	0.1	Worst situation

Estimate the Attenuation on the Optical Link

Here the calculation of the attenuation is made for optical link. Total attenuation (TA) of an elementary cable has been calculated in this section as:

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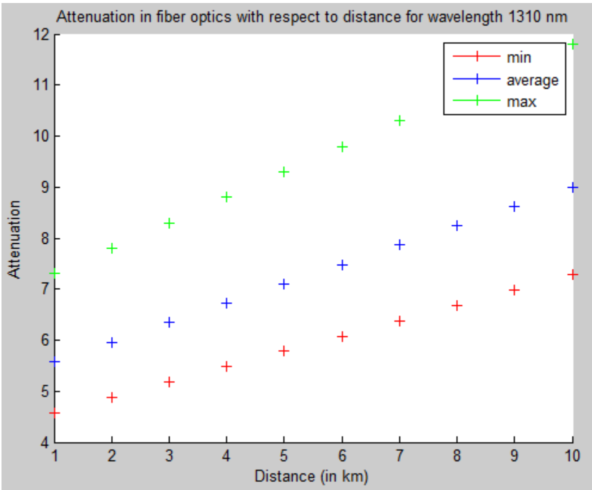

Fig 7 Attenuation in fiber optics with respect to distance for wavelength 1310 nm

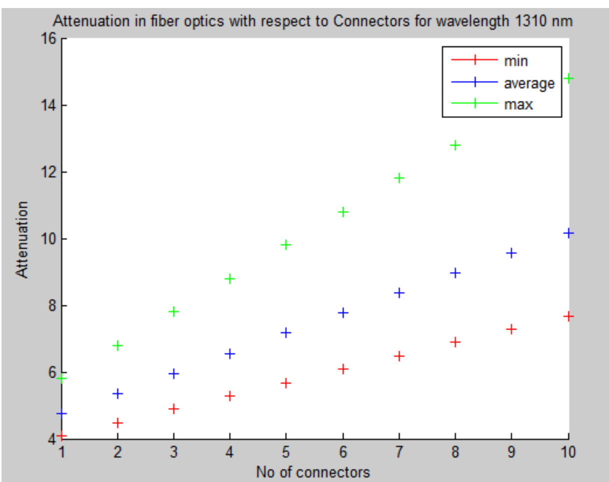

Fig 8 Attenuation in fiber optics with respect to Connectors for wavelength 1310 nm

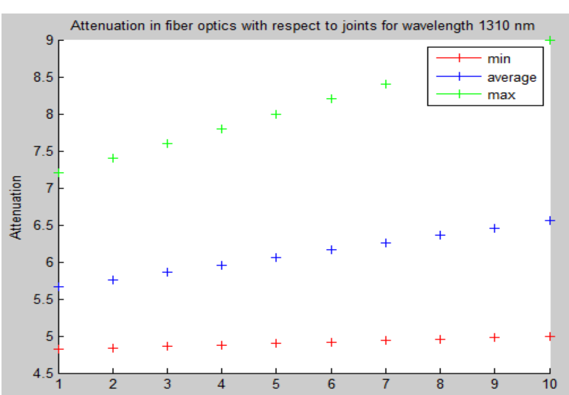

Fig 9 Attenuation in fiber optics with respect to joints for wavelength 1310 nm

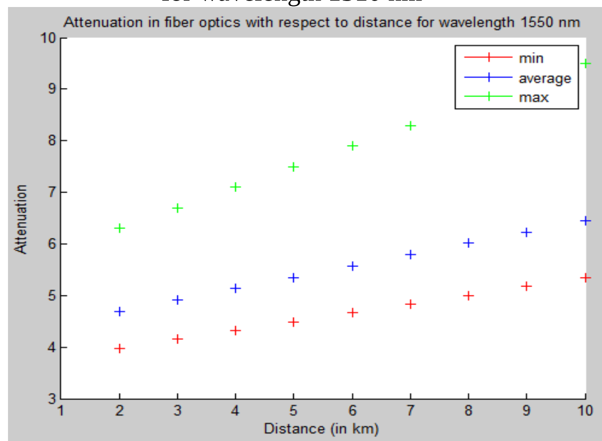

Fig 10 Attenuation in fiber optics with respect to distance for wavelength 1550 nm

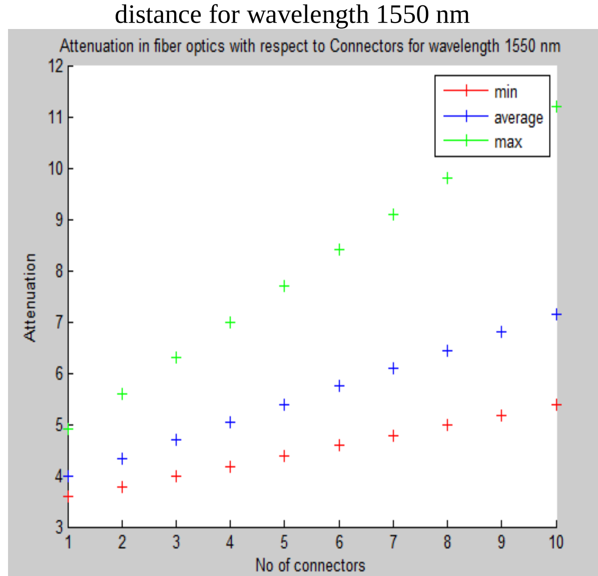

Fig 11 Attenuation in fiber optics with respect to Connectors for wavelength 1550 nm

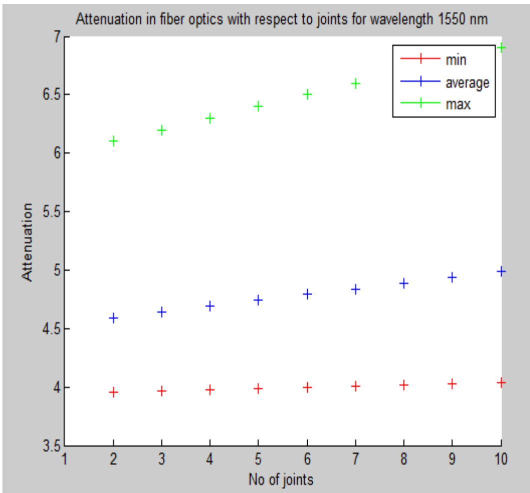

Fig 12 Attenuation in fiber optics with respect to joints for wavelength 1550 nm

[5] CONCLUSION

In the research work the investigation of performance influencing factors in case of fiber optics has been made. Attenuation is a measure of the loss of signal strength or light power that occurs as light pulses propagate through a run of multimode or single-mode fiber. Measurements are typically defined in terms of decibels or dB/km. Analysis of the influencing factors has been made in case of attenuation in case of optical links. Here the data related to attenuation in different cases is collected. Here the calculation of the attenuation is made for optical link. Total attenuation (TA) of an elementary cable has been calculated for wavelength 1310 nm. In this research attenuation in case of wavelengths of 1310 nm, 1550 nm has been simulated. It has been simulated with respect to distance, joints, and connectors. In the research work the attenuation in different cases is calculated. Along with this the comparative analysis of attenuation is also provided in different scenarios.

[6]FUTURE SCOPE

The research work would provide the study of the existing researches related to fiber optics. It would provide the need, scope and working of fiber optics. It also investigates the performance influencing factors of fiber optical devices. The research is based on performance influencing factors of fiber optics in which one is attenuation. This research has considered the attenuation due to increase in distance, number of joints and number of connectors. The research work would also provide the comparative analysis of impact on attenuation considering defined factors in the research work.

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