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Study the Dispersion and Losses in Fiber Optics Communication

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Abstract
This paper presents the disperson of optical fiber in terms of mode of disperson,attenuation,losses etc including optical fiber in terms introduction, which gives an overview of the optical fiber, including the classifications, type, attenuation losses etc. Some basic optical fiber sensor technologies are also reviewed .under this we study about the different type of sensors that introduced the principle and different type of optical sensors based on sensing location i.e. extrinsic and intrinsic sensors, based on operating principle i.e. Process involving Demodulation, Sensor based on Intensity Modulation, Sensors based on Phase Modulation, Sensors based on Polarization Modulation, Sensors based on Wavelength Modulation, which are constructed on application that can measure temperature, stress, pH, , blood flow along with glucose content.

Keyword: Total Internal Reflection (TIR), Refractive Index (RI), Optical fiber sensors (OFS),

1. INTRODUCTION

The System of Optical fiber are vital telecommunication frame for broad band networking all around the world [1].Signals with extensive data transmission rate with short suspension is a significant necessity in contemporary dayuses. These fibers offer huge as well as unmatched transmission bandwidth with almost null latency and arecurrently the broadcasting way of selection for extensive space in addition to bandwidth transmission intelecommunication networking [1]. It uses light pulsations for the relocation data between different points with thehelp of an optical fiber. The data transferred is basically a digital figure made by telephone systems, cable TV houses, as well as the computer systems [2]. It all eventually began in late 1950s when fiber-imaging bundles were first put together which further led to the expansion of Fiber optic research. Over the time the evolution of fiber optics has to grow into most popular and advanced modes of communication available today [2].Optical fiber sensors have witnessed a tremendous development ever since the 1970s and numerousvital substitutions into marketable area have been attained. Optical fiber sensors have been considered as not onlythe alternatives of conventional sensors but also the sole solution in industrial fields, engineering and scientificresearch because of its the specific advantages [2]. The detectors like the interferometry sensors, fiber gratingsensors, photonic crystal fiber sensors and scattering based sensors are outlined as the substantial cases of progressin Optical fiber sensors. Additionally, several budding areas, where the Optical fiber sensors are supposed to bethe sole operative key, are also talked over.

2. Basics of optical fiber

This particular fiber is a cylindrical waveguide that is a dielectric and prepared from low-loss materials, which are generally silicon dioxide. The structures which are di-electric waveguide are used to bound and direct light along its pathway [4]. The components of a Dielectric wave guide consist of three parts which a core, cladding, coating or buffer.Basic structure of the core is rod which is cylindrical and is made up of dielectric material is known as Core. Its constituent resource is glass which has a RI (n_1). The propagation of light is primarily along the Fiber core [5]. The typical diameter of core area varies from 0.005nm to 0.1nm [6]. A dielectric material is used to make the layer of cladding with RI as n_2. The RI of the material which is cladding is lower than that of the material used in core [5]. The functions executed by cladding are decreasing loss of light from core into the surrounding air, decreasing scattering loss at the surface of the core, protecting .A hollow metal conductor that provides a path to guide microwaves has a RI which is little more than that of the outer medium (cladding), therefore the light pulses are directed along the axis of the fiber by the phenomenon which is known as TIR [4]. The variation in diameter of cladding portion is around 0.1 to 0.2 meters. [6].

The major categories into which the optical fiber varies is classified between multimode or single mode. The definition of a mode that it is a set containing similar pathways through which rays of light travel through the fiber [7].

2.1 Multimode Fibers

Multimode Fibers only denotes the point that several approaches or rays of light are being carried at the same time over the waveguide. Modes result in formation of the ray of light will only transmit in the core of the fiber at distinct angles within the boundary of acceptance [7]. This variety of fiber have extensively larger basic diameter, in comparison with mono-mode fiber, permitting the superior quantity of modes, and multimode fiber is simpler in connection than mono-mode optical fiber. MM comprise an elementary dimension of 51.5 or 62.5 microns. The core which has larger dimension is accountable to fiber that keep multiple electromagnetic modes that are transverse for a recognized occurrence and polarization phenomenon. When the ray of light arrives in the fiber, it distributes naturally and the multi modes begin to move at the same time along with the lane [8]. These verities of fibers are generally engaged with biomedical uses and arise in two elementary configurations i.e. gradient index and step index [7].

2.1.1 Step-index multimode

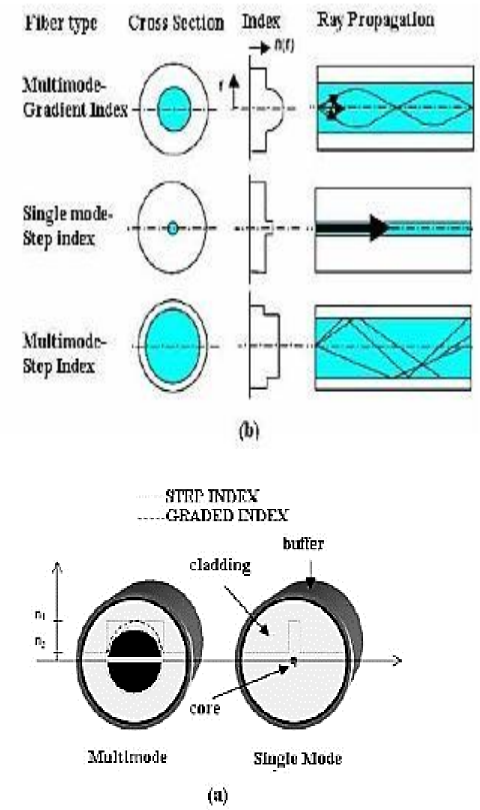
This class of fiber have the simplest structure [7]. It consists of core which have similar refractive index all the way through the fiber [9]. The name of this variety arises from the unembellished difference in refractive index inside the material of the fiber [7]. Abrupt ally or step changes occur in this type of mode.

2.1.2 Graded-index multimode

This range of fiber contains a core whose RI differs with the variation in distance from the fiber axis [9]. There is a keen shift in reduction of refractive index from the core‟s center to the layer of cladding.Gradually changes occur in this mode.

2.2 Single Mode Fibers

Mono-mode fiber or commonly known as 'Single mode fiber‟ has an extravagant advantage of lesser fiber reduction as compared to multi-mode class of the fiber and holds best dependability of each and every beat of the light ray, since it shows little or no dispersion triggered by various modes. Therefore, data can be transferred over larger spaces. A classic core is consisted of a mono-mode fiber which is 9 microns in length [9]. The total internal reflection phenomenon doesn‟t take place plus the notion of „Numerical Aperture (NA)‟ is decreased to its explanation because only single mode is permitted to travel down the pathways of the fiber. It marks the differences between the refractive indices of the layer of cladding and core but has diminutive effect on the transmission of data. The Numerical Aperture for a mono-mode fiber is typically lesser when compared to a multimode variety of fiber. Similar to this class of fiber, initial mono-mode fiber was usually considered as step – index fiber, which means that the RI of the core of fiber is a phase overhead then that of the layer of cladding rather than progressed which can be seen in graded-index fiber [8, 10]. Figure (1) shows the various kinds of optical fibers. [5]



3. Optical Fiber as Waveguides

Fig 1. Variation in optical fibers

This fiber can act as a tubular dielectric waveguide which can transfer radiations to wavelengths inside visible as well as infrared region of the EM spectrum, using the TIR sensation at the edge among the dual media with varying RI. The core consists of minutely greater RI than the cladding layers. Brief meaning of this is only that the border amongst the core layer and the cladding layer turns as a flawless glass. The ray of light drifting through the core is restrained by the mirror to accommodate within it, even when the fiber twists round the corner [1]. Since formation guided ray of light is required, therefore inside fiber light ray must be incident on the core region in a way that after the refraction phenomenon, it results in formation of an angle lesser than critical angle (θc) along axis of fiber. For the combination of ray of light inside optical fiber, light ray should fall inside the boundary of acceptance defined by the acceptance angle by the fiber, and hence experience TIR Phenomenon and results in formation of guided modes which is illustrated in figure (2). If the light ray is incident outside this boundary, then it will lose portion of their power to the layer of cladding at each reflection since they aren‟t directed. The angle of acceptance θc at the fiber cone can be computed on applying of Snell‟s law between tip interface of air and fiber as well as at fiber core and interface of fiber cladding which can be specified by equation mentioned below. [2]

Where:

$\theta_a = \sin^{-1} NA$

NA= ($n_1^2 - n_2^2$)$^{1/2}$

Here, NA is called the Numerical Aperture of the optical fiber and its function is to describe the capacity of light rays association in the optical fiber, n_1 is RI of the core whereas n_2 is RI of cladding.

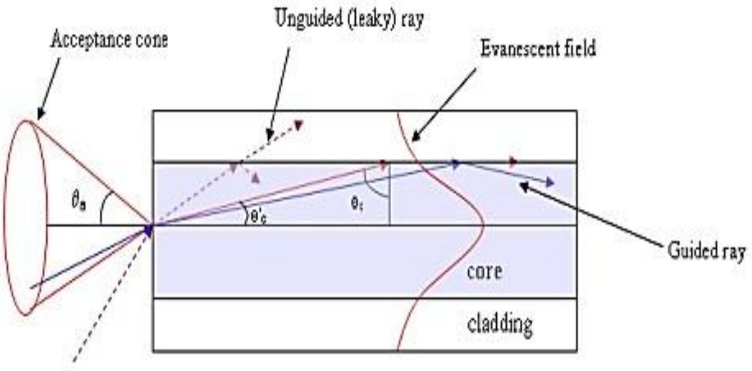


Figure 2. Diagram of an Optical fiber showing distribution of intensity of Light within the fiber [2].

3.1. Dispersion in Optical Fiber

If dispersion phenomenon is taking place inside an optical fiber then it simply means that there is extension of the signal pulse width is going on. There are dual classes of mechanisms of dispersion phenomenon inside fiber: These are following:

3.1.1. Intermodal dispersion

Intermodal means a chromatic dispersion which is dependent chiefly on materialistic fiber. A dual variation in forms of intermodal dispersion phenomenon can be witnessed. The first variation talks about material dispersion and second variation reviews a waveguide dispersion. Intermodal dispersion occurs since there dissimilar variationin shades of rays of light that travel through unlike materials along with varying waveguide arrangements at dissimilar velocities [2].

The Phenomenon of Material dispersion happens for the reason that of the scattering of a light ray pulse which remains reliant on wavelengths communication using the RI of core of fiber. Dissimilar wavelengths propagate at diverse velocities inside the material of the fiber. Unlike wavelength of a light pulsation which pass in a fiber at a particular interval time, leaves through the end of the fiber at a dissimilar time [1]. The function of Material dispersion phenomenon is breadth of basis spectral. The wavelength variation that can circulate inside fiber is specified by the spectral width. This phenomenon is minimized at extended wavelengths [2] and the waveguide dispersal phenomenon happens for the reason that the constant of mode propagation (β) varies with the size of the core compared to the operational wavelength [3]. This dispersion also occurs for the reason that light ray circulates in a different way inside core region of fiber than in the cladding region of fiber. Dispersion in multimode Waveguide is usually neglected for the reason being very minute when related to the phenomenon material dispersion. Whereas fiber material phenomenon and waveguide dispersion phenomenon are inter connected in case of mono-mode fibers. The summation of entire dispersion existing in mono-mode fibers can be reduced by trading material and properties of waveguide which depends on the operational wavelength [2].

3.1.2. Intramodal dispersion

Intramodal dispersion which is commonly known as multimode dispersion ascends due to the difference in grouping speeds for every mode at solo frequency.

3.2 Attenuation in Optical Fiber

The loss in the signal strength is known as an Attenuation. It is directed by different mechanisms which comprises of scattering, winding, absorption and radiation. [3]Attenuation can be categorized in various kind two of themare described below [5]

3.2.1. Intrinsic losses

1. Rayleigh scattering because of spatial variation of RI and varies inversely with λ. It yields an extreme shortfall only inside UV region. But in given sector of wavelength which is about 0.8 µm to 1 µm, a huge shortfall (about 0.6dB/km) can be witnessed.
2. End of infrared absorption because of coupling of silicon and oxygen is there in complex wavelengths which is about 1.4 µm to 1.6µm.
3. End of UV absorption because of transition of electron is present at lesser wavelengths that are about 0.8 µm which further yields a loss of 0.3dB/km

3.2.2. Extrinsic lost:

1. Micro bending.
2. Faulty alignment between fibers.
3. Non-uniform at the boundary of core and cladding

4. OPTICAL FIBER SENSORS

The major application of Fiber optic sensors is for measurement of stuffs like displacement, electric currents, strain, pressure, magnetic fields, temperature and environmental stuffs. Fiber optic sensors have extreme sensitivity and are electrically inactive (which is important for safety in some of applications) [9]. These sensors can be seen in various field of technology. If we talk about communication system, uses of this fiber is unwanted for waves of light being directed along this fiber which is to be influenced with atmosphere, or the data which is being transferred might be tarnished. A fiber optic sensor can sense these result(s) which a certain ecological factor has on light ray being directed with aid of the optical fiber. Consequently, by conducting measurement in the differences in certain factors of light ray passing the fiber optic sensor, the factor of the surroundings that produces the variation in light eligible to be measured [6]. The configuration of the optical fiber is adjusted for detecting function [5, 7]. This variety of detector instrument is named as intrinsic fiber optic sensor. Optical fiber instruments are tremendous contenders for monitoring environmental deviations and they provide many advantages over predictable electrical instruments [5,7].

- Capable to remote sensing.
- Invulnerable to radio frequency and electromagnetic intervention.
- Failure to allow initiation of current.
- Extra toughness to severe situations.
- Extraordinary sensible.
- Insubstantial

4.1 Working Principles

The functioning principle on which fiber optic sensor is grounded on the variation of the light which is guided with help of fiber produced on one of its factors like, wavelength, phase intensity or state of polarization by the factor underneath examination. It is consisted of optical foundations like Light Emitting Diode and Laser diode, optical fiber, detecting/modulating part (that can transduce the restrained to an optical signal), optical indicator and handling electronics (analyzer for optical spectrum and many more). [5, 7]

4.1.1. Extrinsic and intrinsic (On the basics of sensing location)

The fiber optic sensor is fundamentally used to transfer light toward and from an exterior optical instrument where the sensing process occurs. In an intrinsic OFS single or multiple type of the basic factor of the fiber that experience a modification which can be seen in (illustration 3) [5]

6.CONCLUSION

This paper concludes by providing analysis of dispersion and losses in fibre optics cummnication under this we study the different types of Dispersion in Optical Fiber .If dispersion phenomenon is taking place inside an optical fiber then it simply means that there is extension of the signal pulse width is going on. There are dual classes of mechanisms of dispersion phenomenon inside fiber.thuscomparison details of different types of fiber optics communication system.

REFERENCES

1. A. Ghatak and K. Thyagarajan, "Optical Waveguides and Fibers", fundamentals of photonics, University of Connecticut, 2000.
2. J. S. Rickman, "A Comparative Study of Total Hemoglobin Measurement Technology: Noninvasive Pulse Cooximetry and Conventional Methods", M.Sc. thesis, University of Connecticut Graduate School, 2011.
3. A. G. Mignaniy and F. Baldiniz, "Biomedical Sensors Using Optical Fibers", Rep. Prog.Phys., 59, pp.1–28, 1996.
4. G.keiser, "optical fiber communications", Mcgraw-Hill series in electrical engineering, 2nd addition, 1991.
5. Fidanboylu,K., and Efendioglu, H. S., "Fiber Optic SensorsandTheir Applications", 5th International Advanced Technologies Symposium (IATS"09), Karabuk, Turkey, May 13-15, 2009.
6. M.Arumugam,"Optical Fiber Communication-An Overview", PRAMANA-journal of physics, Vol. 57, Nos 5 & 6, pp. 849–869, 2001.
7. L. C.L. Chin, W. M.Whelan, and I. A. Vitkin," Optical Fiber Sensors for Biomedical Applications", Optical- Thermal Response of Laser-IrradiatedTissue, 2nd ed., Springer Science+Business Media B.V. 2011.
8. K. S. Schneider," Fiber Optic Data Communications for the Premises Environment", Cisco Systems, 2008
9. S. Kwan," PrinciplesofOptical Fibers", In partial fulfillment of course requirement for MatE, San Jose State University, 2002.