Study Of Fiber Optics And Its Mathematical Interpretation

Rahul Sharma [1], Dr. Shailesh Kumar Singh [2]
M.Sc. Physics [1], Head of Department [2]
Monad University, Hapur [1,2]

Abstract
Some basic aspects related to fiber optics have been studied. Some of the history of fiber development leading to data transmission in many parts of the world is discussed. Through a lot of research and design, the basic theory of fiber operation and the method of improving fiber performance are discussed. Connectors and connectors were compared and short- and long-haul fiber networks were discussed. Fiber plays many roles in the business world. Emphasis is placed on the use of fiber optics for communications applications. With the development of modernization, communication has become an important part of human life, and it cannot be ignored. The communication process involves the generation, transmission, reception and interpretation of information. The wide bandwidth used for signal transmission with low latency is a key requirement in today's applications. Optical fiber is now the transmission medium for long-distance data, and it has high data rate transmission for telecommunication networks.

Keywords: Fiber optics, Communications Applications, Mathematical Expression

1. Introduction

1.1 Fiber optics

The Romans must have felt happy for themselves the day they invented the lead pipes 2000 years ago. Finally, they had an easy way to move their water from one place to another. Imagine what you're going to do with the modern "pipe" of fiber-optic cables that can make phone calls and e-mails around the world at seven seconds. They are used to the idea that information is transmitted in different ways. When they talk on a landline, a wired cable carries our voices to a wall socket, where another wire takes it to the local phone. Mobile phones operate differently: they transmit and receive information via invisible radio waves, a technique called wireless because they do not use cables. Fiber optics works in a third way. Send information encoded in the beam of light by a glass or plastic tube. It was originally developed for binoculars in the 1950s to help doctors see the inner part of the human body without opening it first. In the 1960s, engineers discovered a way to use the same technology to send phone calls at light speed (typically up to 186,000 miles or 300,000 kilometers per second in a vacuum, but they go down to about two thirds of that speed).

1. 2 Optical technology

The fiber optic cable consists of thin glass or plastic filaments not known as optical fibers; the cable can contain only two or several hundred threads. Each strand is less than ten human hair thickness and can carry approximately 25,000 telephone calls, so a full fiber optic cable can carry several millions of calls. Fiber optic cables transfer information between two locations using full light (light-based) technology.

Suppose they want to send information from your computer to a friend's home on the street using fiber optics. They can connect your computer to a laser, which turns the computer's electrical information into a series of light pulses. The laser will then be launched through the fiber optic cable. After traveling on the cable, beams of light will appear at the other end. Their friend will need a photoelectric cell (light detection component) to turn the light pulses back into electrical information that your computer can understand. Therefore, the entire device will be like a high-tech version of the phone that you can make using two packets of baked grain and a rope.

1.3 1How fiber-optics works

The light travels through the fiber optic cable that repeatedly bounces on the walls. Each small photon (particle of light) from the tube returns like a sleigh landing to an ice rink. Now they can expect a beam of light, traveling in a transparent glass tube, just to filter through the edges. But if the light falls on the glass at an actually low angle (less than 42 degrees), it reflects again, as if the glass already mirror. This phenomenon is called total internal reflection. It's one of the things that keeps light inside the tube.

The other thing that keeps light in the tube is the cable structure, which consists of two separate parts. The main part of the cable, in the middle, is called the nucleus, the part through which the light passes. Wrapped around the outer part of the core of another layer of glass called coating. Paint work is to keep light signals inside the nucleus. They can do this because it is made of a different type of glass. (Technically, the coating has a lower refractive index.

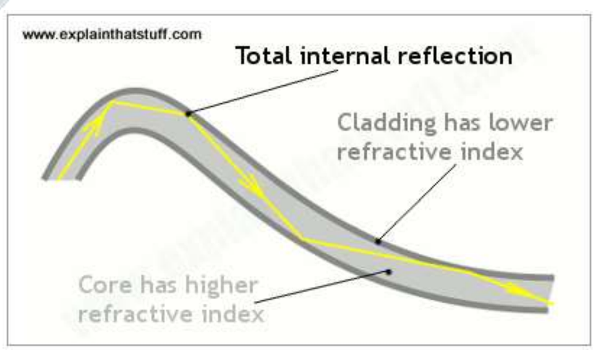

Fig1.Types of fiber-optic cables

Optical fibers carry light signals down in so-called positions. This sounds technically, but it means different ways to travel: the first way is simply the path followed by the ray of light across the fiber. One way is to go straight through half of the fiber.

Another fiber is bouncing at a shallow angle. Other modes include bouncing fibers at other angles, more or less sharply.

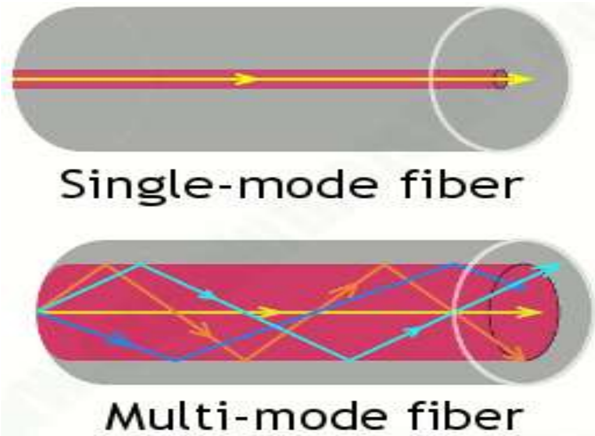

Fig 2 mode of fiber

2. Background

1. Sun et al. (2019) stud of a biometric sensor from Aptamer was proposed and demonstrated to detect non-labeled thrombin based on fiber optic interference. The bio sensor probe can be easily made by reducing commercial coated double fibers of up to 5 µm in diameter and providing high sensitivity to the refractive index of 1,660 nm / RIU. Changes are determined by plotting the offset of the wavelength of the fall in the transmission spectrum with a refractive index variable index. With the help of surface activation of the thrombin tetramers, the proposed optical fiber sensor demonstrates its ability to detect non-characteristic thrombin with detectable concentrations of less than 0.1 µm, with high specificity at different concentrations of pure and mixed thrombin. Solutions

2. Liu et al. (2019) in this thesis they suggest multimodal fiber with a coating of 30 µm-core and fluoridated to achieve a wide bandwidth covering 850-940 nm. In the experiment, a 4 × 25 Gb / s SWDM error transmission using a commercial transceiver was reported using 250-meter fibers.

3. Zhang et al. (2019) study of Refractive optical fiber refractometers based on broadband coupling from core to shell for a wide range of refractive index measurements have been suggested empirically. The detection probe has a Bragg fibrous mesh (TFBG) with an initial fiber liner mirror. The "paint" mirror is manufactured by a 0.3 micron thick gold film with a transparent opening that allows all light directed by the pulp to pass through but reflects the light in the paint. The TFBG works on mixing the forward diffusion mode with the rear diffusion coating modes and the coating patterns again reflected in the TFBG by the fiber "mirror" mirror and connected to the fiber nucleus by the same TFBG. With this special design, it is now possible to observe all the transferred coating modes effectively in reflection. Compared to the TFBG refractometer for fiber-to-fiber coupling, our sensor shows the operating range of the refractive index of a much wider range with a linear sensitivity of 528 nm / RIU. An adjustable laser was used to improve measured accuracy and a sensitivity of 7973 dB / RIU was obtained, with the detection of 10-6 RIUs detected. The sensor works with a cross sensitivity that can be highly controlled because the basic mode depends on the temperature but is not sensitive to the surrounding refractive index.

4. Lu et al. (2019) in this paper they display a switchable generation of LP11a / b modes through the dual-mode optical audio adapter. Within the configuration of the output of the laser inside the cavity with the blocking mode, this approach has very potential applications in the system of division of division mode, and particle handling.

5. Huang et al. (2019) photonic crystal fiber (PCF) is proposed for photovoltaic modification. The E7 liquid crystal is accurately filled in one of the most internal air holes in the PCF and forms a fiber optic coupler, and the resonant wavelength can be adjusted to a sensitivity of 5,594 nm / Vrms when applying external voltage. The device can act as a photovoltaic transformer / transformer and shows a response time of approximately 47 and 24 ms, respectively from 1414 nm to more than 1,700 nm. The proposed structure is expected to have potential applications in the detection of electric field and photovoltaic devices that can be adjusted along the wavelength.

6. Gan et al. (2019) in this thesis they achieve input I / O devices for multi-core 7 core fibers with very low interference at -62 dB. The maximum loss of insertion and Fresnel reflection is less than 1.2 dB and -58 dB, respectively.

7. Wang et al. (2019) study of Traditional grid engraving technology typically incorporates only one fiber-optic network (FBG) at the fiber optic core. A new point-to-point technique of laser femtosecond has been shown to include multiple FBGs in parallel, the so-called FBG (PI-FBG), with different wavelengths or the same reflection in one standard unit nucleus. Fiber mode. Single or multi-length PI-FBGs showed one or several peaks in the reflection spectrum, respectively. The length of PI-FBGs can be reduced to hundreds of micrometers to increase the spatial accuracy of sensors based on FBG. The ultra-short PI-FBG of 500 µm can be used to achieve a very high temperature to detect a high spatial temperature of less than 1 mm, a linear sensitivity of 15.0 pm/°C and a wide measurement range of up to 1100 ° C, The conventional FBG-based sensor with a low spatial resolution of more than 1 cm and a small measurement range of up to 300 ° C. The reflection wavelength, polarized loss and total width can be improved in the middle of the maximum, to achieve the desired PI-FBG by changing the spatial distribution and the number of PI-FBG network barriers. PI-FBG is not sensitive to bending, which reduces measurement errors caused by bending. Therefore, you will find our PI-FBGs potential applications in the fields of fiber optic, communication and laser sensors.

8. Zhang et al. (2019) in this paper they designed and manufactured new ring fibers with a refractive index profile to suppress media coupling caused by partial bending. The transfer of two OAM modes through fibers 50 km long without the use of MIMO equalization is also shown experimentally.

9. Jiang et al. (2019) propose of they illustrate the manufacture of long helical networks (HLPG) in the fibers that maintain polarization using CO2 laser. The PDL of the network is measured at more than 30 decibels at the resonance length. HLPG was found to have a high sensitivity to the refractive index at -7248.6 nm / RIU when the refractive index changes within 1.4470-1.4600, a 158.8 m / c temperature sensitivity and a 3.16 µm / The torsional sensitivity was measured on the basis of the density variation at 5.98 dB / rad / m (common directional torsion) and -5.97 dB / (rad / m) (directional twisting), respectively. The installed network devices have promising applications such as high sensitivity fiber sensors, PDL compensators, etc.

10. Lao et al. (2019) in this paper they provide an optical fiber sensor that uses long-range surface plasmon resonance (SPR) and an interpreter to reasonably detect very small changes in resonance because of the refractive index. The Bragg fiber-optic grid, which is decorated with standard single-mode fibers, shifts the light into fiber cladding. SPR spouts on a micrometer scale with a 50-nm gold layer. Reduction of target protein detection, thrombin, is enhanced by resonance between long-range SPR and localized SPR in 13 nanometer-diameter nanoparticles linked across protein molecules. The sensor shows a constant and repeatable response to the thrombin concentration up to the detection limit of 1 nm, three orders of magnitude more sensitive than previous fiber optic sensors. At the same time, it does not require exact temperature control due to the removal of cross-sensitivity of heat inherent in TFBG devices (core mode). High sensitivity, simplicity, small size and remote sensing potential open up many new opportunities for environmental, biological and medical detection.

3. Mathematical Modelling

The communication system uses 10 km of fiber with a loss of 2.5 dB / km. look for output power if input power is 400 mW.

Solution: From in Equation, take advantage of that relationshipy $= 10^{x}$ifx $=$ log,

$$\mathrm{Loss}_{\mathrm{dB}} = 10\log\left(\frac{\mathrm{P}_{\mathrm{out}}}{\mathrm{P}_{\mathrm{in}}}\right)$$

$$\frac{Loss_{dB}}{10} = log\left(\frac{P_{out}}{P_{in}}\right)$$

Which converts, then, $10^{\frac{\mathrm{Loss}_{\mathrm{dB}}}{10}} = \left(\frac{P_{out}}{P_{in}}\right)$

Thus, as a final point, they have

$$P_{out} = P_{in} \times 10^{\frac{Loss_{dB}}{10}}$$

For 10 km of fiber with 2.5-dB/km loss characteristic, the loss $_{\mathrm{dB}}$ becomes

$$Loss_{dB} = 10km \times (-2.5dB/km) = -25dB$$

Plugging this back into Equation 8-2b,

$$P_{out} = (400mW) \times 10^{\frac{-25}{10}} = 1.265mW$$

Photovoltaic energy in optical fiber systems is usually expressed in dBm, which is a dB that is assumed to be 1 megawatt. Optical energy can refer here to the source of the laser source or simply to the power source somewhere in the system. If P is in equation in milliseconds, equation given for power at dBm, with reference to input of one mW:

$$P(dBm) = 10log\left(\frac{P}{1mW}\right)$$

Through the optical power expressed in dBm, the output power can be determined in any part of the system once the power input is expressed in dBm and the loss of the individual components is expressed as dB. It is important to note that an optical source with a 1 mW input port can be expressed as 0 dBm, as shown in Equation 8.3. For each 3 dB loss, power is reduced by half. Thus, photovoltaic energy doubles to an increase of 3 dB. For example, a 3 dB optical source contains P of 2 MW, while a source of 6-d has a P of 0.25 MW, as can be verified by equation.

4. Conclusion

This paper details the communication concept Characteristics and applications for electrical wires, especially optical fibers. we also focus on architecture and fiber optic systems (link budget) design). A lot of development can be done by doing more research and fiber work. We need it to build a faster, more reliable infrastructure that will be a major demand for a growing population in the future.

References

1. D. Sun, L. Sun, T. Guo and B. Guan, "Label-Free Thrombin Detection Using a Tapered Fiber-Optic Interferometric Aptasensor," in *Journal of Lightwave Technology*, vol. 37, no. 11, pp. 2756-2761, 1 June1, 2019. doi: 10.1109/JLT.2018.2878762
2. Y. Liu, L. Ma, W. Xiao, R. Wang and Z. He, "Wide Band Multimode Fiber with a 30 μm-Core and Fluorine-Doped Cladding to Support Error-Free 4×25 Gb/s SWDM Transmission Over 250 Meters," *2019 Optical Fiber Communications Conference and Exhibition (OFC)*, San Diego, CA, USA, 2019, pp. 1-3 Z.
3. Zhang, T. Guo and B. Guan, "Reflective Fiber-Optic Refractometer Using Broadband Cladding Mode Coupling Mediated by a Tilted Fiber Bragg Grating and an In-Fiber Mirror," in *Journal of Lightwave Technology*, vol. 37, no. 11, pp. 2815-2819, 1 June1, 2019. doi: 10.1109/JLT.2018.2838538
4. J. Lu, L. Meng, F. Shi and X. Zeng, "A Mode Locked Fiber Laser with Switchable High-Order Modes using Intracavity Acousto-Optic Mode Converter," *2019 Optical Fiber Communications Conference and Exhibition (OFC)*, San Diego, CA, USA, 2019, pp. 1-3.
5. Y. Huang *et al*., "Tunable Electro-Optical Modulator Based on a Photonic Crystal Fiber Selectively Filled With Liquid Crystal," in *Journal of Lightwave Technology*, vol. 37, no. 9, pp. 1903-1908, 1 May1, 2019. doi: 10.1109/JLT.2019.2894910
6. L. Gan *et al*., "Ultra-Low Crosstalk Fused Taper Type Fan-In/Fan-Out Devices for Multicore Fibers," *2019 Optical Fiber Communications Conference and Exhibition (OFC)*, San Diego, CA, USA, 2019, pp. 1-3.
7. Y. Wang *et al*., "Parallel-Integrated Fiber Bragg Gratings Inscribed by Femtosecond Laser Point-by-Point Technology," in *Journal of Lightwave Technology*, vol. 37, no. 10, pp. 2185-2193, 15 May15, 2019. doi: 10.1109/JLT.2019.2899585
8. R. Zhang *et al*., "A Novel Ring-Core Fiber Supporting MIMO-Free 50km Transmission Over High-Order OAM Modes," *2019 Optical Fiber Communications Conference and Exhibition (OFC)*, San Diego, CA, USA, 2019, pp. 1-3
9. C. Jiang, Y. Liu, Y. Zhao, C. Mou and T. Wang, "Helical Long-Period Gratings Inscribed in Polarization-Maintaining Fibers by CO2 Laser," in *Journal of Lightwave Technology*, vol. 37, no. 3, pp. 889-896, 1 Feb.1, 2019. doi: 10.1109/JLT.2018.2883376.
10. J. Lao *et al*., "Gold Nanoparticle-Functionalized Surface Plasmon Resonance Optical Fiber Biosensor: In Situ Detection of Thrombin With 1 n·M Detection Limit," in *Journal of Lightwave Technology*, vol. 37, no. 11, pp. 2748-2755, 1 June1, 2019. doi: 10.1109/JLT.2018.2822827