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Fundamentals and working principle of optical fiber transmission system

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Abstract

This paper presents the basic fundamentals in fiber optics and working principle of optical fiber transmission system. Fiber optics transmission system has altered the telecommunication industry. It has likewise made its essence generally felt inside the information organizing group too. Utilizing fiber optic link, optical interchanges have empowered telecommunications connects to be made over substantially more noteworthy separations and with much lower levels of misfortune in the transmission medium and conceivably most imperative of all, fiber optical correspondences has empowered considerably higher information rates to be suited.

Keywords: fiber, optical, transmission, principle

Introduction

The Light is utilized as a part of optoelectronics and optical fiber media transmission for information transmission, in optical fiber interferometers, optical fiber lasers, sensors and optical fiber modulators. The expression "light" in fiber transmission, despite the fact that regularly utilized, is not generally exact: Light characterizes just the electro-attractive radiation from the visual scope of 380-780 nm, while in numerous applications, e.g. optical fiber transmission, the electro-attractive radiation from close infrared range (850 nm, 1310 nm, 1550 nm) is utilized. The figures demonstrate the electromagnetic radiation range and permits to find the radiation utilized as a part of optical fiber transmission. In additionally parts of this book the expressions "light" and "electro-attractive radiation from close infrared range" will be utilized interchangeably [1].

Development of optical fiber transmission system

Since the earliest days of telecommunications there has been an ever increasing need to transmit more data even faster. Initially single line wires were used. These gave way to coaxial cables that enabled several channels to transmit over the same cable. However these systems were limited in bandwidth and optical systems were investigated.

Optical communications became a possibility after the first lasers were developed in the 1960s. The next piece of the jigsaw fell into place when the first optical fibers with a sufficiently low loss for communications purposes were developed in the 1970s. Then, during the late 1970s a considerable amount of research was undertaken. This resulted in the installation of the first optical fibre telecommunications system. It ran over a distance of 45 km and used a wavelength of 0.5 mm and had a data rate of just 45 Mbps - a fraction of what is possible today.

Since then, considerable improvements have been made in the technology. Data rates have improved and in addition to this the performance of the optical fibre has been improved to enable much greater distances to be achieved between repeaters. As an indication of this the speeds that can now be achieved along through a fibre optic system exceed 10 Tbps.

When the first fibre optic transmission systems were being developed, it was thought that the fibre optic cabling and technology would be prohibitively expensive. However, this has not been the case and costs have fallen to the extent that fibre optics now provides the only viable option for many telecommunications applications. In addition to this it is also used in many local area networks where speed is a major requirement.

Components of optical fibre transmission system

Any fibre optic data transmission system will comprise a number of different elements. There are three major elements (marked in bold), and a further one that is vital for practical systems:

- Transmitter (light source)
- Fibre optic cable
- Optical repeater
- Receiver (Detector)

Other key components

- dispersion-compensating modules
- semiconductor and fiber amplifiers (mostly erbium-doped fiber amplifiers, sometimes Raman amplifiers) for maintaining sufficient signal powers over long lengths of fibers, or as preamplifiers before signal detection
- optical filters (e.g. based on fiber Bragg gratings) and couplers
- optical switches and multiplexers (e.g. based on arrayed waveguide gratings); for example, optical add/drop multiplexers (OADMs) allow wavelength channels to be added or dropped in a WDM system
- electrically controlled optical switches
- devices for signal regeneration (electronic or optical regenerators), clock recovery and the like
- various kinds of electronics e.g. for signal processing and monitoring
- computers and software to control the system operation

The different elements of the system will vary according to the application. Systems used for lower capacity links, possibly for local area networks will employ somewhat different techniques and components to those used by network providers that provide extremely high data rates over long distances. Nevertheless the basic principles are the same whatever the system.

In the system the transmitter of light source generates a light stream modulated to enable it to carry the data. Conventionally a pulse of light indicates a "1" and the absence of light indicates "0". This light is transmitted down a very thin fibre of glass or other suitable material to be presented at the receiver or detector. The detector converts the pulses of light into equivalent electrical pulses. In this way the data can be transmitted as light over great distances.

Here are different types of optical fibers applied in telecommunications, computer networks and other applications. Optical waveguides can be divided into various types considering:

a. structure (cylindrical, birefringent, planar, strip)
b. number of modes (single- or multimode fiber)
c. the refraction index profile (step-index or gradient-index fiber)
d. material (glass, plastic, semiconductor)
e. dispersion (natural dispersion, dispersion shifted fiber DSF, dispersion widened fiber DWF, reverse dispersion)
f. signal processing ability (passive – data transmission, active – amplifier)
g. polarization (classic, polarization maintaining/preserving, polarizing optical fiber)

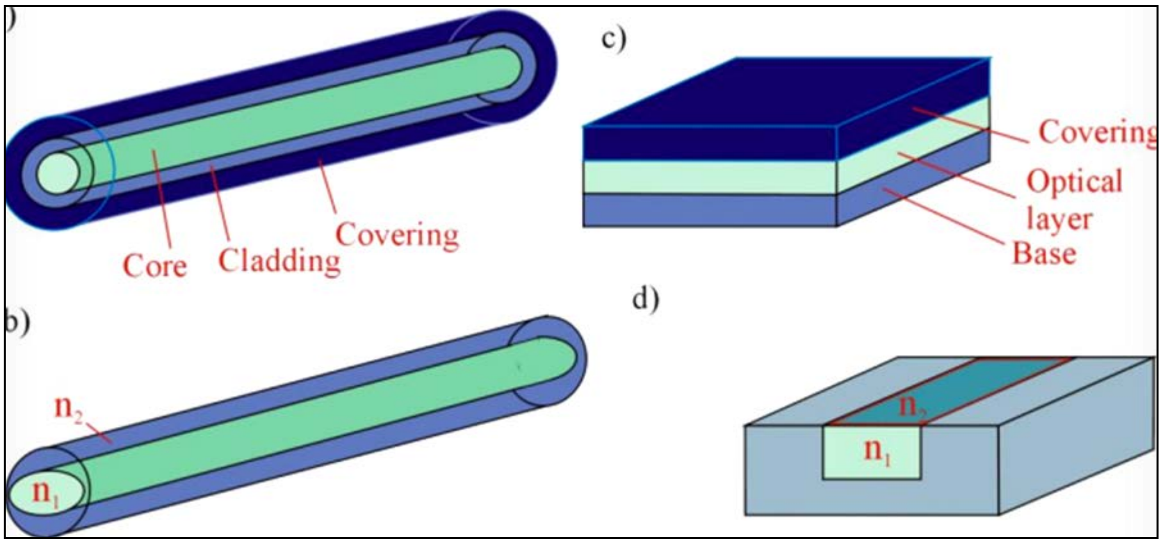

Fig 1: Cylindrical waveguide (a), birefringent waveguide (b), planar waveguide (c), strip waveguide (d).

Historical Perspective

In any communication system, signal from one end is transmitted via a transmitter and received at other end by a matched receiver through a low loss medium. Similarly, the data and various information from different users are transmitted from one end of the transmitter and received at the other end using low loss medium.

Telephone signals are transmitted through copper wire at frequencies up to 4 KHz. Higher frequencies are transmitted through atmosphere from ground to satellite and then back to ground. Broadband communication at super high frequencies (10 14 Hz) is done over optical fiber cables which are satisfactory working at 1300 nm, 1550 nm and in future it will go to higher wavelengths around 2550 nm.

In the electromagnetic spectrum infrared region (0.7–100mm) lies between microwave frequency and visible spectrum, (0.32 – 0.7mm). First generation optical fiber communication was designed at 820 nm but after 1980, the optical fiber communication is done at 1300 nm and 1550 nm. The 1550 nm range provides the minimum attenuation of light signals over long distances but this wavelength has much larger dispersion.

At present, most of the systems, which are operational in the world, are based on 1550 nm laser wavelength in the near infrared region. This wavelength, 1550 nm is selected after studying the fiber attenuation with respect to wavelength from 300 nm to 2000 nm. It is found that fiber attenuation is 0.5 dB/km for 1300 nm and it is around 0.2 dB/km for 1550 nm wavelength. So, optical fiber transmitter, optical receiver and fiber cable suitable for 1300nm and 1550 nm are successfully developed and are now operating worldwide. Further low attenuation losses are seen in fibers around 2.55 mm. research work is going on so that attenuation losses of the order of 0.001 dB/km may be achieved on longer wavelengths of optical fiber cables.

In the late nineteenth and mid twentieth hundreds of years, light was guided through twisted glass bars to enlighten body holes. Down to earth applications, for example, close interior light amid dentistry seemed right on time in the twentieth century. Picture transmission through tubes was shown autonomously by the radio experimenter Clarence Hansell and the TV pioneer John Logie Baird in the 1920s. In the 1930s, Heinrich Lamm demonstrated that one could transmit pictures through a heap of unclad optical filaments and utilized it for inside restorative examinations, yet his work was to a great extent forgotten [10].

Working Principle of Optical Fiber Transmission System

An optical fiber is a cylindrical dielectric waveguide (non-conducting waveguide) that transmits light along its axis, by the process of total internal reflection. The fiber consists of a core surrounded by a cladding layer, both of which are made

of dielectric materials [52] To confine the optical signal in the core, the refractive index of the core must be greater than that of the cladding. The boundary between the core and cladding may either be abrupt, in step-index fiber, or gradual, in graded-index fiber.
The transmitter is associated with the one end of the fiber link. Electronic heartbeats are changed over by the transmitter into light heartbeats and the optical flag gets sent through the fiber link. A beneficiary on the flip side disentangles the optical flag into advanced heartbeats.
The center of the link is encompassed by a cladding which mirrors the light once again into the center and dispenses with light from getting away from the link. This is called add up to inner reflection.
At the point when light is sent through the center of a fiber optic link, the light continually ricochets off the cladding, which is exceptionally intelligent, similar to a mirror-lined divider. The cladding does not ingest any light permitting complete inward reflection and enabling the light to go far separations without losing its force.
The revelation of lasers impacted the improvement of fiber optics. Lasers and LED's can create a gigantic measure of light in a little territory, which can effectively utilized as a part of fiber optics.
Laser diodes are intricate semiconductors that change over an electrical current into light. The way toward changing over the electrical flag into light is significantly more effective on the grounds that it produces less warmth than a conventional light.

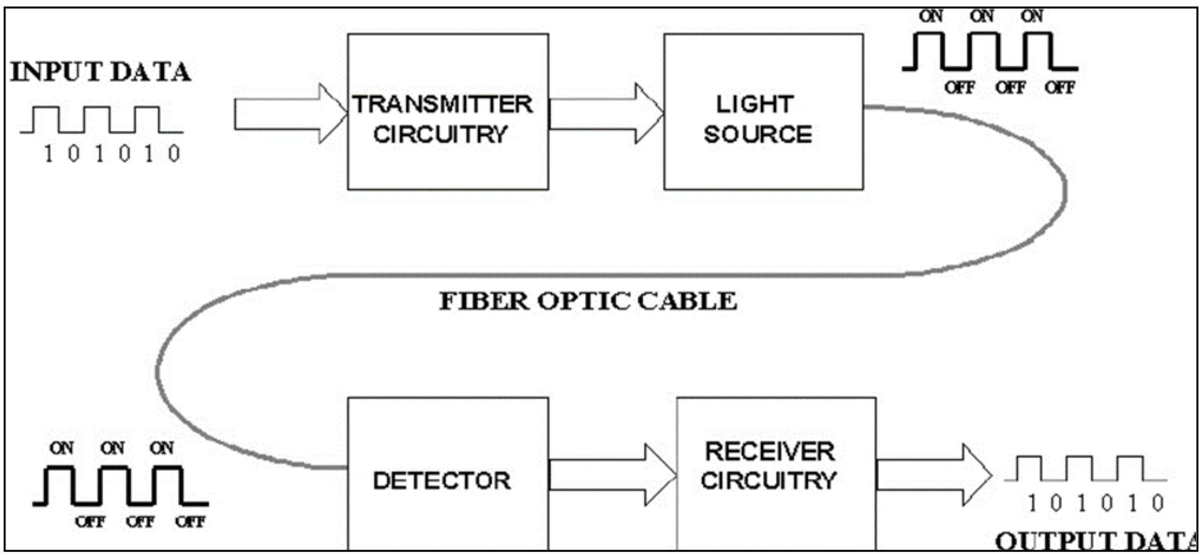

Fig 2: Working of Fiber Optics transmission System Conclusion

Conclusion
Optical Fiber Transmission System has made imperative commitments to the various fields, particularly with respect to physics, telecommunication, medical and communication. A standout amongst the most valuable attributes of optical filaments is their capacity to enter the moment ways and difficult to-achieve ranges of the human body. Yet, maybe the best commitment of the twentieth century is the mix of fiber optics and gadgets to changed media communications.

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