ISSN: 2277-9655
Impact Factor: 4.116
CODEN: IJESS7

IJESRT
INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES & RESEARCH TECHNOLOGY

ADVANCED TRENDS IN FIBER OPTIC COMMUNICATION

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ABSTRACT
Fiber optic communication systems are important communication system for broadband networks. Optical fibers provide large bandwidth with high speed for signal transmission which is the main requirement of today's communication. Fiber optic communication systems are now the transmission medium of choice for long distance and high data rate transmission in Telecommunication networks. With advancement repeaters are mounted with maximum distance which also eliminates interference from lightening, cross talk and electromagnetic radiations. This paper focuses on fiber optic communication systems including their key technologies, and also discusses their advanced technology.

KEYWORDS: Bandwidth, Broadband, Optic communication

INTRODUCTION
The main reason behind fiber optic communication is high bandwidth services such as database queries, home shopping, high definition communicating video, remote education, telemedicine& e-health, grid computing.[1]the optical fiber having light weight & high bandwidth characteristics & resistant to interference from electromagnetic radiation &cross talk ,becomes the main choice for heavy demand long line telephone communication system.[2]Fiber optic communication uses wave length division multiplexing for transmission of data. In Fiber optic communication information is process in the optical domain for the purpose of boosting, multiplexing, de-multiplexing, switching, filtering, and correlation.

Although the associated benefits of utilizing optical fiber for communication are large bandwidth, small size & light weight, flexible, electrical isolation, immunity to interference & cross talk, signal security, low transmission loss.

HISTORY & EVOLUTION OF FIBER OPTICS
After invention of the Laser in 1960s & series of technology development in optical fiber around 1970s, practical light wave communication system implemented worldwide in 1978.these system operate in near infra-red region of the electromagnetic spectrum & use light fiber for the transmission. The first generation fiber optic system was developed in 1970,are used to carry telephony signals at 6Mbps over the distance around 10 Km. The second generation fiber optic system was developed in 1980,are used to carry data rate beyond tera bits /sec over the distance of Hundreds of Km without the need to restore the signal fidelity. In Third generation, in 1990 the capacity of fiber lines were enhanced by adding more independent signals carrying wavelength on single fiber & increasing speed of signal carried by each wavelength.[3]The 4th generation of fiber optic systems through use of optical amplifiers instead of repeaters, and utilized wavelength division multiplexing (WDM) to increase data rates. By 1996, transmission of over 11,300Km with a data rate of 5Gigabits/second had been established using submarine cables [4].The fifth generation fiber optic communication systems uses
The Dense Wave Division Multiplexing (DWDM) to further increase data rates.

BASIC PRINCIPLES OF FIBER OPTICCOMMUNICATION
The optical fiber consists of the transparent core with refractive index N_1 with transparent cladding slightly lower refractive index N_2.The cladding reduces radiation losses in air & it increases mechanical strength of fiber. It protect core from absorbing surface contaminants. The fiber encapsulated in an abrasion resistant

plastic material called buffer sheath or jacket. It provides additional strength to fiber & isolates it from small geometrical irregularities, distortion or roughness of adjacent surface.

WORKING PRINCIPLE OF OFC

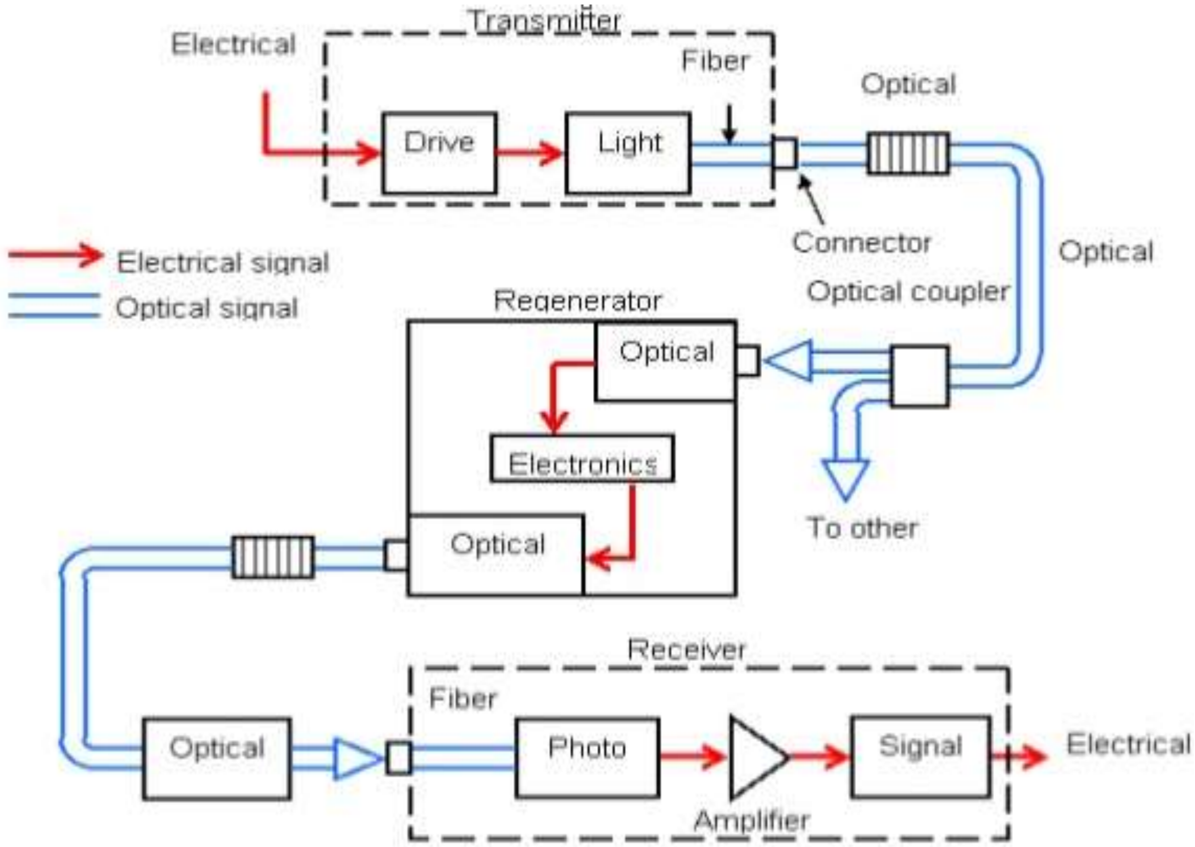

Fig.2. Working Diagram of OFC

Transmitter Terminal

Information input

Information signal transmitted may be voice, video or computer datathe information may be an audio conversation, a stream of data from one computer to another, or several simultaneous television broadcasts.

Transmitter

1. **Encoder/Signal shaping circuit**

Its purpose is to make the transmitted signal compatible to the communication channel by limiting the effective bandwidth of the transmission.

2. **Modulator / Driver**

In optical communications, intensity modulation (IM) is a form of modulation in which the optical power output of a source is varied in accordance with some characteristic of the modulating signal

3. **Optical Source**

Then digital pulses are used to drive a powerful light source off and on very rapidly. In low cost system for shorter distance communication LED is used. Color of light emitted depends on material used to construct LED.

Another commonly used light source for long distance communication is LASER. LASER generates single high frequency light beam these are then fed into FOC.

Transmissions Medium

Fiber

An optical fiber is flexible and transparent made of very pure glass (silica) not much wider than a human hair that acts as a waveguide, or "light pipe", to transmit light between the two ends of the fiber.

Repeater

Repeaters are used in long transmission system for avoiding losses of signal strength.Since the light is greatly attenuated when it travels over long distances at some point it may be too weak to be recovered reliably.
To overcome this attenuation problem, special relay stations are used to pick up the light beam, convert it back into electrical pulses that are amplified and then again transmitted the pulses on another light beam.

Receiver Terminal

Optical Detector

An optical detector is a transducer that converts an light signal into an electrical signal. It does this by generating an electrical current proportional to the strength of incident light.At the receiving end a light sensitive device/ light detector i.e. Photodiodes generally avalanche photo diode is used to detect light pulses.Light detector converts light pulses into electrical signal.

Amplifier & Reshaper

These electrical pulses are reshaped and amplified back into digital form, then these are fed to decoder.

Decoder/Demodulator

A DAC is used where the original voice or video is recovered.A demodulator is an electronic circuit that is used to recuperate the information content from the modulated carrier wave.

Information Output

The information out may be an audio conversation, a stream of data from one computer to another, or several simultaneous television broadcasts depending on the detected input.

PRINCIPLE OF RAY PROPAGATION

This is the most interesting thing about optical fiber cables. Such an crucial part of modern day communication system works on an very simple property of light ray i.e. **Total Internal Reflection**. As we all know that when light ray is passing from thicker (refractive index is higher) dielectric medium to a rarer (refractive index is lower) dielectric medium then from the point of incidence at the interface it bends away from the normal. When the occurrence angle is sufficiently high such that the angle of refraction is 90º then it is called critical angle. Now if light ray falls at the edge of the two mediums at an angle greater than the critical angle then the light ray gets returned back to the creating medium with high efficiency (around 99.9%) i.e. total internal reflection occurs. With the help of innumerable total internal reflections light waves are propagated along the fiber with low loss as shown in figure. In this context, two parameters are very critical namely **Acceptance Angle** and **Numerical Aperture**.

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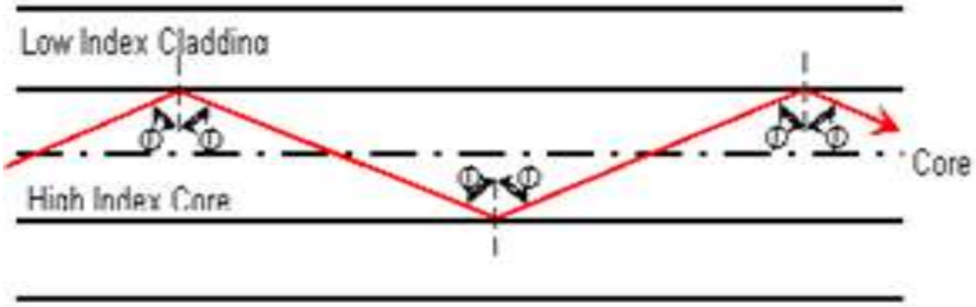

Fig.3.Total Internal Reflection in OFC

Acceptance angle is the maximum angle to the axis at which light may enter the fiber in order to be propagated and is denoted by θa in figure3. The Numerical Aperture is a measure of light collecting ability of the fiber. It is independent of fiber core diameter. The relationship between the acceptance angle and the refractive indices of core, cladding and air, leads to the definition of Numerical Aperture which is given by

$$NA = (n1^2-n2^2)^{1/2} = n_0 \sin \theta a$$

Where n_0 is the refractive index of air.
Acceptance cone is defined as the range of angles for rays to be transmitted by total internal reflection with in the fiber core.

TYPES OF OPTICAL FIBERS

According to the refractive index profile optical fibers can be classified into two categories namely **Step index fibers** and **Graded index fibers** which are described below.

Step index fibers

If the refractive index profile of a fiber creates a step change at the core cladding interface then it is called as step index fiber. A multimode step index fiber is shown in figure (a), these fibers has large core diameter hence many paths through which light can travel. The light ray travelling the straight path through the center reaches the end before other rays which follows zigzag path .Therefore in this fiber

Intermodal dispersion occurs. Therefore they used for short haul, limited bandwidth & low cost application. For multimode step index fiber optical source is LED. A single mode fiber has a small core diameter & cladding diameter at least 10 times the core diameter. With this fiber a light ray can travel only one path parallel to only one path parallel to the axis. Therefore intermodal dispersion is zero.It is used for wide band long haul transmission. It uses Laser as a source. Single mode step index fiber light wave is displayed in figure7(b).

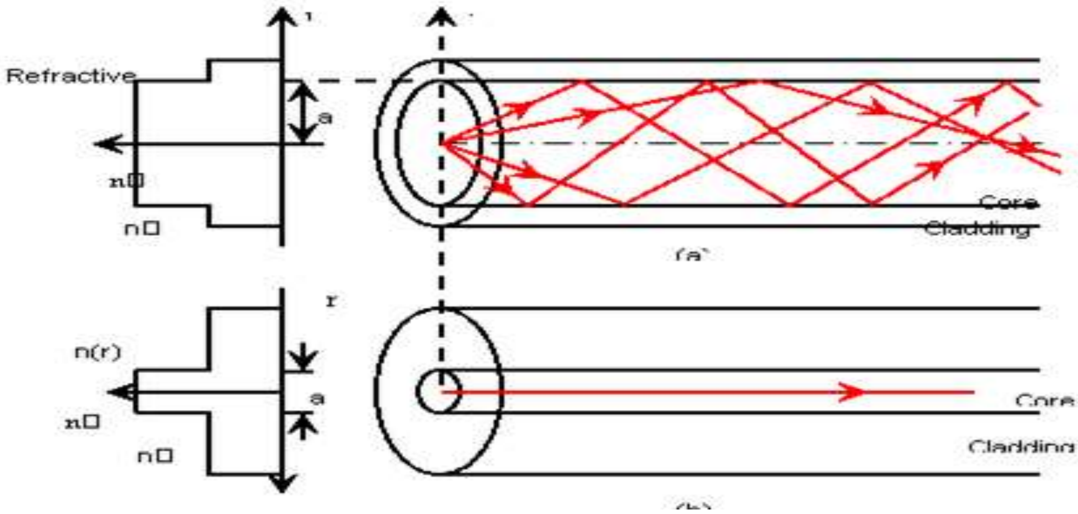

Fig.4. Multimode & Single mode Step index Fiber

Graded index fibers

The graded index fibers have reducing core index n(r) with radial distance from a maximum value of n1 at the axis to a constant value n2 outside the core radius a in the cladding as shown in figure. The graded index fiber gives best results for multimode optical transmission for parabolic refractive index profile. Due to this special kind of refractive index profile multimode graded index fibers show less intermodal spreading than its counterpart i.e. multimode step index fibers.

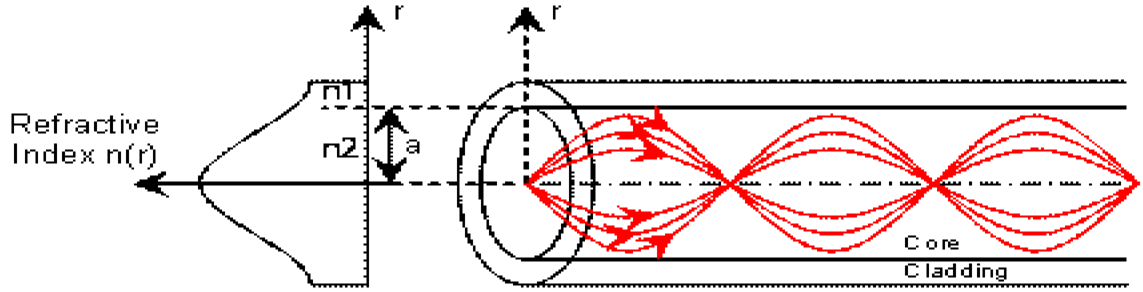

Fig.5. Multimode graded index fiber

INCOMING TRENDS IN OPTICAL COMMUNICATION

Fiber optics communication is the future of high data rate Communication. The development of fiber optic communication has been driven by improvement in technology and increased Request for fiber optic communication. It is predictable to Continue into the future, with the development of new and more advanced communication technology. Below are some of the future trends in fiber optic communication.

All Optical Communication Networks

The advantage of All-optical networks is their skill to perform the entire signal processing, routing and switching in the optical dominion where there is no need to switch to the electrical domain to offer for a data rate increase (Subramaniam *et al.* 1996). Current fiber optic transmitters and receivers are only collected to address one data transfer rate which is still a drawback if the data rate is to be increased further thereby requiring a system replacement. However, this would not be compulsory in an all-optical network. The trend, however, still grieves from a number of serious drawbacks. For example, reading optical signal headers, on-the-fly optical signal switching with the header content and real-time wavelength substituting are a few such limitations that are still being examined to achieve an all-optical network.

Multi-Terabit networks

Dense wavelength division multiplexing (DWDM) is the optical signal multiplexing within the 1550 nanometer band in order to use the potential and cost of erbium doped fiber amplifiers (EDFAs). The EDFAs are capable of boosting any optical signal within their operating range. The fundamental DWDM opens the door for multi terabit transmission which is driven by concentration to obtain more bandwidth in fiber optic networks. A one terabit network is thus obtained by commissioning a 10Gb/s data rate in grouping with 100 DWDM channels which can be stretched to 40Gb/s at present via 100 DWDM channels. Research at present are directing on higher bandwidth 100Gb/s systems which are very costly and may only suitable for long-haul transmission systems

Perfections in Optical Transmitter/Receiver Technology

In fiber optics communication, it is important to achieve high Superiority transmission even for optical signals with distorted waveform and low signal to noise ratio during transmission. Research is ongoing to advance optical transceivers employing new and advanced modulation technology, with outstanding Chromatic dispersion and Optical Signal to Noise Ratio (OSNR) tolerance, which will be suitable for ultra-long haul communication systems. Also, better error correction codes, which are more effective than the present BCH concatenated codes are proposed to be available in the nearest future.

Polymer Optic Fibers

Polymer optical fibers offer many advantages when related to other data communication solutions such as copper wires, wireless communication systems, and glass fiber. In comparison with glass optical fibers, polymer optical fibers Offer an easy and less inexpensive processing of optical signals, and are more flexible for plug interconnections [5]. The use of polymer optical fibers as the transmission media for aircrafts is presently under research by different Research and Development groups due to its profits. The German Aerospace Center have concluded that "the use of Polymer Optical Fibers multimedia fibers appears to be possible for Upcoming spacecraft applications [6]. Also, in the future, polymer optical fibers will likely transfer copper cables for the last mile connection from the telecommunication company's last updated Distribution box and the functioned end consumer [7]. The future Gigabit Polymer Optical Fiber standard will be based on Tomlinson-Harashima Precoding, Multilevel Pulse Amplitude Modulation, and Multilevel Coset Coding Modulation.

CONCLUSION

The fiber optics communications industry is an ever developing one, the growth experienced by the industry has been huge this past years. In most of the communication systems copper wires are replaced by fiber optic cable There is still much more effort to be done to support the need for faster data rates, innovative switching.

The advance trend is projected to continue in the future as innovations already attained in the laboratory will be Extended to practical utilization thereby leading to a future generation in fiber optics communications.

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