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BASIC REVIEW OF OPTICAL FIBER, ADVANTAGES, LOSSES AND FUTURE TRENDS

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ABSTRACT

Fiber optic systems are important telecommunication infrastructure for world-wide broadband networks. This paper deals with the Basic communication model and the types of fibers for the optical fiber communication system. Then the different technologies in optical fiber communication along with their features are discussed briefly. Finally the general system of optical fiber communication is briefly mentioned along with its advantages and limitations. The future aspects of the Optical Fiber is also shows that how the new technology can be overcome the shortcomings of the old one.

INTRODUCTION

An optical fiber is a thin fiber of glass or plastic that can carry light from one end to the other. The study of optical fibers is called fiber optics, which is part of applied science and engineering. Optical fibers are mainly used in telecommunications, but they are also used for lighting, sensors, toys, and pecial cameras for seeing inside small spaces. It is sometimes used in medicine to see inside people, like down their throat. Any fiber 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)
- Fiber optic cable
- Optical repeater
- Receiver (Detector)

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.

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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.

Fiber types

Step-index multimode fiber has a large core, up to 100 microns in diameter. As a result, some of the light rays that make up the digital pulse may travel a direct route, whereas others zigzag as they bounce off the cladding. These alternative pathways cause the different groupings of light rays, referred to as modes, to arrive separately at a receiving point. The pulse, an aggregate of different modes, begins to spread out, losing its well-defined shape. The need to leave spacing between pulses to prevent overlapping limits bandwidth that is, the amount of information that can be sent. Consequently, this type of fiber is best suited for transmission over short distances, in an endoscope, for instance. Graded-index multimode fiber contains a core in which the refractive index diminishes gradually from the center axis out toward the cladding. The higher refractive index at the center makes the light rays moving down the axis advance more slowly than those near the cladding. Also, rather than zigzagging off the cladding, light in the core curves helically because of the graded index, reducing its travel distance.

Block Diagram of System

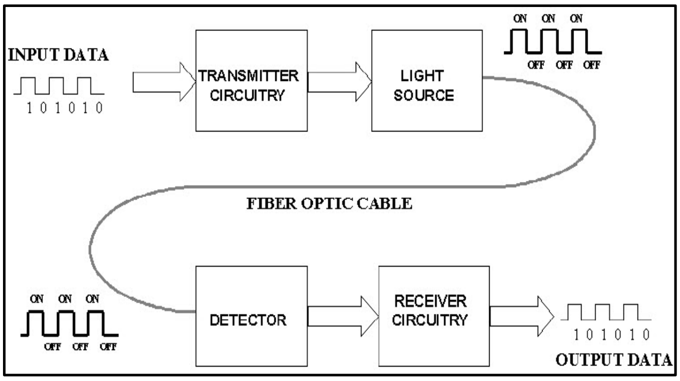

Fig. 1. Basic analog optical fiber communication system

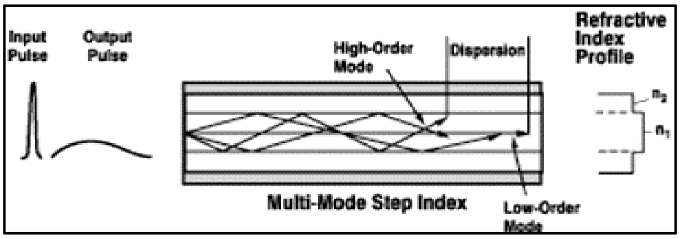

Fig. 2. Step-index Multimode Fiber

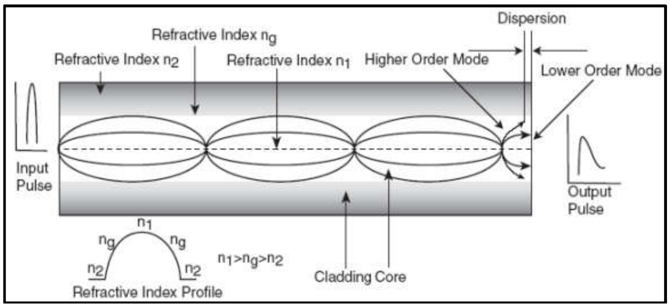

Fig. 3. Graded-index Multimode Fiber

The shortened path and the higher speed allow light at the periphery to arrive at a receiver at about the same time as the slow but straight rays in the core axis. The result: a digital pulse suffers less dispersion.

Single-mode Fiber

Single-mode fiber allows for a higher capacity to transmit information because it can retain the fidelity of each light pulse over longer distances, and it exhibits no dispersion caused by multiple modes. Single-mode fiber also enjoys lower fiber attenuation than multimode fiber. Thus, more information can be transmitted per unit of time. Like multimode fiber, early single-mode fiber was generally characterized as step-index fiber meaning the refractive index of the fiber core is a step above that of the cladding rather than graduated as it is in graded-index fiber. Modern single-mode fibers have evolved into more complex designs such as matched clad, depressed clad and other exotic structures.

Multimode Fiber

Multimode fiber, the first to be manufactured and commercialized, simply refers to the fact that numerous modes or light rays are carried simultaneously through the waveguide. Modes result from the fact that light will only propagate in the fiber core at discrete angles within the cone of acceptance. This fiber type has a much larger core diameter, compared to single-mode fiber, allowing for the larger number of modes, and multimode fiber is easier to couple than single-mode optical fiber. Multimode fiber may be categorized as step-index or graded-index fiber. Multimode Step-index Fiber Figure 2 shows how the principle of total internal reflection applies to multimode step-index fiber. Because the core's index of refraction is higher than the cladding's index of refraction, the light that enters at less than the critical angle is guided along the fiber.

Advantages of optical fiber communication

Bandwidth: Fibre optic cables have a much greater bandwidth than metal cables. The amount of information that can be transmitted per unit time of fibre over other transmission media is its most significant advantage. With the high performance single mode cable used by telephone industries for long distance telecommunication, the bandwidth surpasses the needs of today's applications and gives room for growth tomorrow.

Low Power Loss: An optical fibre offers low power loss. This allows for longer transmission distances. In comparison to copper; in a network, the longest recommended copper distance is 100m while with fibre, it is 2000m.

Interference: Fibre optic cables are immune to electromagnetic interference. It can also be run in electrically noisy environments without concern as electrical noise will not affect fibre.

Size - In comparison to copper, a fibre optic cable has nearly 4.5 times as much capacity as the wire cable has and a cross sectional area that is 30 times less.

Weight: Fibre optic cables are much thinner and lighter than metal wires. They also occupy less space with cables of the same information capacity. Lighter weight makes fibre easier to install.

Safety: Since the fibre is a dielectric, it does not present a spark hazard.

Security: Optical fibres are difficult to tap. As they do not radiate electromagnetic energy, emissions cannot be intercepted. As physically tapping the fibre takes great skill to do undetected, fibre is the most secure medium available for carrying sensitive data.

Flexibility: An optical fibre has greater tensile strength than copper or steel fibres of the same diameter. It is flexible, bends easily and resists most corrosive elements that attack copper cable.

Cost: The raw materials for glass are plentiful, unlike copper. This means glass can be made more cheaply than copper.

Disadvantagesof optical fiber communication

Cost: Cables are expensive to install but last longer than copper cables.

Transmission: Transmission on optical fibre requires repeating at distance intervals.

Fragile: Fibres can be broken or have transmission loses when wrapped around curves of only a few centimetres radius. However by encasing fibres in a plastic sheath, it is difficult to bend the cable into a small enough radius to break the fibre.

Protection: Optical fibres require more protection around the cable compared to copper

Losses in fiber-optic cables

Losses in fiber-optic cables generally occur due to absorption, scattering, dispersion and bending of cables. There are two types of bending losses – macroscopic and microscopic. The former, macroscopic type occurs when bends in the cable assembly cause certain modes not to be reflected thereby resulting in losses due to cladding. In the latter, microscopic bending type, slight bends in the cable surface causes light to be reflected a certain angles when there is no more reflection. Absorption losses occur due to heating of ionic impurities resulting in light diffusion at the end of the cable. There are two types of absorption losses intrinsic and extrinsic losses. The intrinsic absorption occurs by the interaction with one or more glass components (Xu *et al.* 2001).

The phenomenon occurs when photonic units interact with electrons in the valence band. The process results in excitation to a higher energy medium closer to the ultraviolet region. Extrinsic absorption is also termed impurity absorption which results from the presence of transitory metal ions (e.g. iron, chromium or cobalt) from OH ions. Dispersion losses occur when optical signal travelling within a cable is distorted. The distortion is either intermodal or intramodal (Yaman*et al.* 2006). Intermodal distortion occurs as a result of pulse broadening due to propagation delay differences between modes in a multi-mode fiber. In the intermodal dispersion, pulse spreading occurs within a single mode due to material or waveguide dispersion. In material dispersion which is also regarded as spectral or chromatic dispersion, results due to refractive index variation. The variation occurs as a function of wavelength which causes pulse spreading even when various wavelengths follow the same trajectories. The waveguide dispersion occurs when the optical signal is passed through the fibre. During this process, 80% of the optical signal strength is confined to the core whereas 20% is confined into the cladding

Future trends in fiber optics

Communication

A. All Optical Communication Networks

An all fiber optic communication is envisioned which will be completely in the optical domain, giving rise to an all optical communication network. In such networks, all signals will be processed in the optical domain, without any form of electrical manipulation. Presently, processing and switching of signals take place in the electrical domain, optical signals must first be converted to electrical signal before they can be processed, and routed to their destination. After the processing and routing, the signals are then re-converted to optical signals, which are transmitted over long distances to their destination. This optical to electrical conversion, and vice versa, results in added latency on the network and thus is a limitation to achieving very high data rates.

B Improvements in Laser Technology

Improvements in Laser Technology Another future trend will be the extension of present semiconductor lasers to a wider variety of lasing wavelengths [12]. Shorter wavelength lasers with very high output powers are of interest in some high density optical applications. Presently, laser sources which are spectrally shaped through chirp managing to compensate for chromatic dispersion are available. Chirp managing means that the laser is controlled such that it undergoes a sudden change in its wavelength when firing a pulse, such that the chromatic dispersion experienced by the pulse is reduced. There is need to develop instruments to be used to characterize such lasers. Also, single mode tunable lasers are of great importance for future coherent optical systems. These tunable lasers lase in a single longitudinal mode that can be tuned to a range of different frequencies

C. Laser Neural Network Nodes

The laser neural network is an effective option for the realization of optical network nodes. A dedicated hardware configuration working in the optical domain and the use of ultra-fast photonic sections is expected to further improve the capacity and speed of telecommunication networks [12]. As optical networks become more complex in the future, the use of optical laser neural nodes can be an effective solution.

D. Improvements in Optical Transmitter/Receiver Technology

Improvements in Optical Transmitter/Receiver Technology In fiber optics communication, it is important to achieve high quality transmission even for optical signals with distorted waveform and low signal to noise ratio during transmission. Research is ongoing to develop optical transceivers adopting new and advanced modulation technology, with excellent 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 efficient than the present BCH concatenated codes are envisioned to be available in the nearest future.

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