Optical Fibre Communication

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Abstract— Fibre optic communication has revolutionized the telecommunications industry. It has also made its presence widely felt within the data networking community as well. Using fibre optic cable, optical communications have enabled telecommunications links to be made over much greater distances and with much lower levels of loss in the transmission medium and possibly most important of all, fiber optical communications has enabled much higher data rates to be accommodated. As a result of these advantages, fibre optic communications systems are widely employed for applications ranging from major telecommunications backbone infrastructure to Ethernet systems, broadband distribution, and general data networking.
Keywords: Fibre Optic, Telecommunication

I. INTRODUCTION

Now we are in the twenty first century, the era of 'Information technology'. There is no doubt that information technology has had an exponential growth through the modern telecommunication systems. Particularly, optical fiber communication plays a vital role in the development of high quality and high-speed telecommunication systems. Today, optical fibers are not only used in telecommunication links but also used in the Internet and local area networks (LAN) to achieve high signaling rates. 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.

A. Optical Fibre:

An optical fiber cable is a type of cable that has a number of optical fibers bundled together, which are normally covered in their individual protective plastic covers. Optical cables are used to transfer digital data signals in the form of light up to distances of hundreds of miles with higher throughput rates than those achievable via electrical communication cables. All optical fibers use a core of hair-like transparent silicon covered with less refractive indexed cladding to avoid light leakage to the surroundings. light or the optical signals are guided through the silica glass fibers by total internal reflection. A typical glass fiber consists of a central core glass (_50 µm) surrounded by a cladding made of a glass of slightly lower refractive index than the core's refractive index. The overall diameter of the fiber is about 125 to 200µm. Cladding is necessary to provide proper light guidance i.e. to retain the light energy within the core as well as to provide high mechanical strength and safety to the core from scratches.

Based on the refractive index, we have two types of fibers (a) Step index fiber (b) Graded index fiber.

1) Step Index fiber:

In the step index fiber, the refractive index of the core is uniform throughout and undergoes an abrupt or step change at the core cladding boundary. The light rays propagating through the fiber are in the form of meridional rays which will cross the fiber axis during every reflection at the core cladding boundary and are propagating in a zig-zag manner.

2) Graded Index fiber:

In the graded index fiber, the refractive index of the core is made to vary in the parabolic manner such that the maximum value of refractive index is at the centre of the core. The light rays propagating through it are in the form of skew rays or helical rays which will not cross the fiber axis at any time and are propagating around the fiber axis in a helical or spiral manner.

B. Fibre Optic Transmission System:

Fiber-optic communication is a method of transmitting information from one place to another by sending pulses of light through an optical fiber .Any fibre optic data transmission system will comprise a number of different elements such as

a) Transmitter b) Fibre optic cable c) Optical repeater/amplifier d) Receiver (Detector)

1) Transmitter:

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"The simplest transmitter device is the LED. Its main advantage is that it is cheap, and this makes it ideal for low cost applications. The light emitting diodes are used for short distances and low data rate applications due to their low bandwidth and power capabilities. For longer distances and high data rate transmission, Laser Diodes are preferred due to its high power, high speed and narrower spectral line width characteristics. But these are inherently non-linear and more sensitive to temperature variations.

2) Fibre Optic Cable:

A Fiber Optic Cable consists of four parts such as core, cladding, buffer, and jacket. The core of a fiber cable is a cylinder of plastic that runs all along the fiber cable's length, and offers protection by cladding. Due to internal reflection, the light travelling within the core reflects from the core, the cladding boundary. Cladding is an outer optical material that protects the core. When light enters through the core (dense material) into the cladding(less dense material), it changes its angle, and then reflects back to the core. Buffer is to protect the fiber from damage and thousands of optical fibers arranged in hundreds of optical cables. Fiber optic cables jackets are available in different colors that can easily make us recognize the exact color of the cable we are dealing with. The color yellow clearly signifies a single mode cable, and orange color indicates multimode.

3) Optical Repeater/Amplifier:

There is a maximum distance over which signals may be transmitted over fibre optic cabling. This is limited not only by the attenuation of the cable, but also the distortion of the light signal along the cable. In order to overcome these effects and transmit the signals over longer distances, repeaters and amplifiers are used. Opto-electric repeaters convert the optical signal into an electrical format where it can be processed to ensure that the signal is not distorted and then converted back into the optical format. optical amplifier directly amplify the optical signal without the need to convert the signal back into an electrical format.

4) Receiver (Detector):

Light travelling along a fibre optic cable needs to be converted into an electrical signal so that it can be processed and the data that is carried can be extracted. The component that is at the heart of the receiver is a photo-detector. This is normally a semiconductor device and may be a p-n junction, photo-diode or an avalanche photo-diode. Once the optical signal from the fibre optic cable has been applied to the photo-detector and converted into an electrical format it can be processed to recover the data which can then be passed to its final destination.

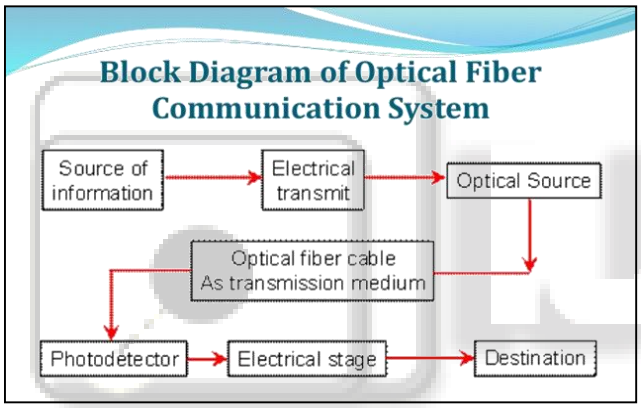

Fig. 1: Block diagram of Optical Fibre Communication

II. Advantages of Fibre Optics for Communications

A. Bandwidth:

Fiber optic cables have a much greater bandwidth than metal cables. The amount of information that can be transmitted per unit time of fiber over other transmission media is its most significant advantage. The optical carrier frequency is in the range 10^{13} to 10^{15} Hz, while the radio wave frequency is about 10^{6} Hz. Thus the optical fiber yields greater transmission bandwidth than the conventional communication systems and the data rate or number of bits per second is increased to a greater extent in the optical fiber communication system.

B. Low Power Loss:

An optical fiber offers low power loss, which allows for longer transmission distances. In comparison to copper, in a network, the longest recommended copper distance is 100m while with fiber, it is 2 km. Due to the usage of the ultra-low loss fibers and the erbium doped silica fibers as optical amplifiers, one can achieve almost lossless transmission. In the modern optical fiber telecommunication systems, the fibers having a transmission loss of 0.002 dB/km are used.

C. Interference:

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

D. Small Size and Weight:

Fiber optic cables are developed with small radii, and they are flexible, compact and lightweight. The fiber cables can be bent or twisted without damage. Further, the optical fiber cables are superior to the copper cables in terms of storage, handling, installation and transportation, maintaining comparable strength and durability.

E. Security:

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

F. Flexibility & Cost:

An optical fiber has greater tensile strength than copper or steel fibers of the same diameter. It is flexible, bends easily and resists most corrosive elements that attack copper cable. The raw materials for glass are plentiful, unlike copper. This means glass can be made more cheaply than copper

III. Disadvantages of Optical Fiber Cable

A. Difficult to Splice:

The optical fibers are difficult to splice, and there are loss of the light in the fiber due to scattering. They have limited physical arc of cables. If you bend them too much, they will break.

B. Can't Be Curved:

The transmission on the optical fiber requires repeating at distance intervals. The fibers can be broken or have transmission losses when wrapped around curves of only a few centimeters radius.

C. Fragility:

Optical fiber is rather fragile and more vulnerable to damage compared to copper wires. You'd better not to twist or bend fiber optic cables.

D. Attenuation within an Optical Fibre:

Although fibre optic cables offer a far superior performance to that which can be achieved with other forms of cable, they nevertheless suffer from some levels of attenuation such as Loss associated with the impurities, Loss associated with the cladding, Loss associated with the wavelength.

IV. Conclusion

Fiber optics communication is definitely the future of data communication. The evolution of fiber optic communication has been driven by advancement in technology and increased demand for fiber optic communication. It is expected to continue into the future, with the development of new and more advanced communication technology. The world-wide

need for increased bandwidth availability has led to the interest in developing multi-terabit optical networks. Presently, four terabit networks using 40Gb/s data rate combined with 100 DWDM channels exists. Researchers are looking at achieving even higher bandwidth with 100Gb/s. Now a day Polymer optical fibers offer many benefits when compared to other data communication solutions such as copper cables, wireless communication systems, and glass fiber. In comparison with glass optical fibers, polymer optical fibers provide an easy and less expensive processing of optical signals, and are more flexible for plug interconnections. We can achieve high quality telecommunication at a lower cost. We can expect a great revolution in optical fiber communication within a few years by means of solutions.

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