FIBER OPTIC TRANSMISSION: ARCHITECTURES, TECHNOLOGIES AND INNOVATIONS, APPLICATIONS, TYPES, TESTING AND TROUBLESHOOTING

Julius Obidinnu
Cross River University of Technology

Prince Ana
Cross River University of Technology

FIBER OPTIC TRANSMISSION: ARCHITECTURES, TECHNOLOGIES AND INNOVATIONS, APPLICATIONS, TYPES, TESTING AND TROUBLESHOOTING

Okwong Atte[1]; Julius Obidinnu[2]; Prince Ana[3]
[1], [2], [3]: Department of Computer Science, Cross River University of Technology, Calabar, Nigeria

ABSTRACT
The purpose of this study is to provide insights on the developments and advances in the use of optic fiber as carriers of information. It provides much information concerning the historical development, architecture, maintenance, troubleshooting and the advantages of fiber optic transmission over copper or electrical transmission. Fiber optic systems are important telecommunication infrastructure for world-wide broadband networks. Optical fibers provide enormous transmission bandwidth with negligible latency, and are now the transmission medium of choice for long distance and high data rate transmission in telecommunication networks. This article gives an overview of fiber optic communication systems, including their architectures, key technologies and innovations, applications, types, testing and troubleshooting.

Keywords: fiber optic transmission, fiber optic architectures, fiber optic technologies and innovations, fiber optic applications, fiber optic types, fiber optic testing and troubleshooting

1.0 INTRODUCTION

Optical fiber are commonly used in telecommunication systems. They are also in use for illumination, sensors and imaging optics. Optical fiber is known as the safest and most efficient channel for information transfer. It has overriding advantages over copper cabling in several areas Noshada (2012). This article focuses on the use of optical fiber cables for information dissemination and current usage over copper cabling.

In fiber optic transmission, data is transmitted using guided media. Guided transmission media uses a cabling system that guides the data signals along a specific path; such media can also be referred to as bound media. An optical fiber is a transparent thin fiber usually made of glass or plastic for transmitting. Light fiber optics is the branch of science and engineering concerned with such optical fibers (Wikipedia, 2013).

The fiber optic cable has been in use for some years and it is becoming preferred to copper cabling. The major constraint users of fiber optic cables have is high cost. They are expensive; this could be attributed to its design and architecture. Unlike copper cables that transmit data by the use of electronic signals, optical fibers transmit data by sending modulated pulse of light. For this reason it is not susceptible to electromagnetic interference (Parvco, 2001).

Optic fiber have several applications in diverse areas of human endeavours, such as illumination, microphones, and sensors, imaging optics, amplifiers and hydrophones for seismic operations. These use have induced innovation in the fiber optic discipline. For instance “recent advances in fiber and optic communications technology have reduced signal degradation so far that no regeneration of the optical signal is needed over distances of hundreds of kilometers. This has greatly reduced the cost of optical networking, particularly over undersea span where the cost and reliability of repeaters is one of the key factors determining the performance of the whole cable system” (Steinke, 2002).

We consider fiber optic transmission a topical issue because of its advantages over copper cables in long haul networks with higher bandwidths spanning longer distances than electrical cabling can provide. Its benefits include an exceptionally low data loss, high data carrying capacity, immunity to electromagnetic interference, high electrical resistance, low weight, much smaller cable size, importance in security systems and in a situation where optical fiber cables are run alongside each other for long distances they, do not experience crosstalk which indeed is a major plus to optical fiber applications (Steinke, 2002).

2.0 TYPES OF OPTIC FIBER

There are two major types of optical fibers; single mode and multimode. The single mode fibers have a smaller core compared with the multimode, which have multiple paths. The single and narrow path within the single mode fiber restricts propagation to a single and direct path, which can achieve speeds of many gigabits/second over hundreds kilometers (see fig 1).

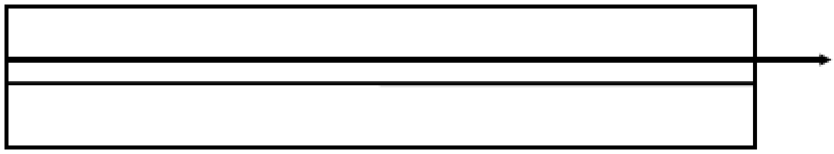

Fig 1: Single Mode Optic Fiber (Source Wikipedia)

Similarly, a multimode fiber, as presented in Figure 2, has an input ray of light reaching the receiver over multiple paths. The first ray of light arrives in a direct path and the second ray of light in a reflected path. It has been observed that the difference in delay between the two paths cause interference between the rays; the level of interference is dependent on the duration for pulses, which is relative to the delays of the paths (Steinke, 2002).

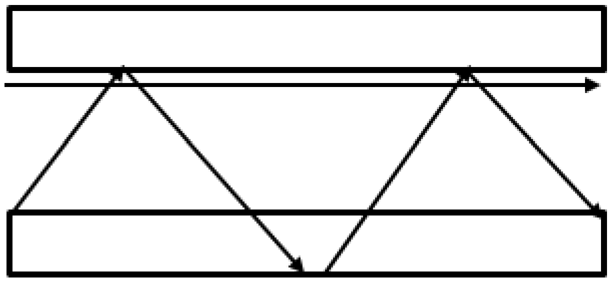

Fig 2: Multimode Optic Fiber-Multiple Rays Follow Different Paths. (Source Wikipedia)

3.0 OPTICAL FIBER: DESIGN/ARCHITECTURE

Optical fiber consists of a cylinder of glass (core) as indicated in Figure 3a and 3b which is surrounded by a concentric layer of glass (cladding). Information travels through the core in the form of fluctuating beam of light. Most cores always have higher optical density (refractive index) compared with the cladding. The ratio of the indexes of refraction of glass defines a critical angle Θ. When a ray of light from the core approaches the cladding at an angle less than Θ, it will completely be reflected back to the core, which guides the ray within the fiber. When the impurities in the glass are minimized, attenuation is reduced.

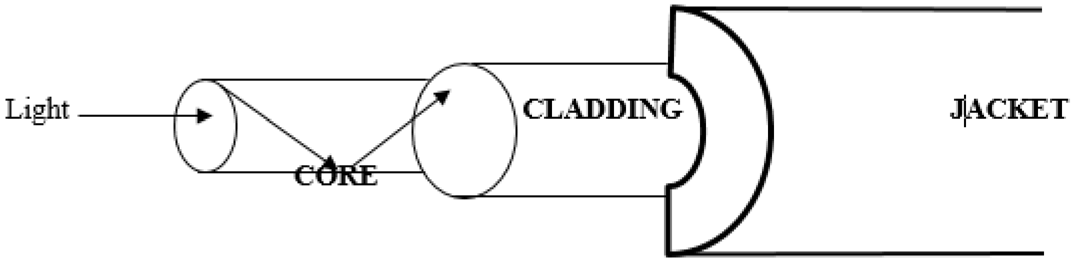

Fig 3a: Geometry of Optical Fiber (Source Wikipedia)

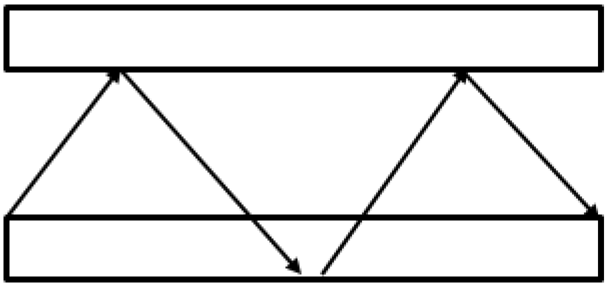

Fig 3b: Reflection in Optical Fiber (Source Wikipedia)

4.0 USES OF OPTICAL FIBERS

Optical fibers can be used for sensors in the measurement of temperature, pressure, strum and other parameters. Hydrophones are another application of optical fiber which are used in seismic operation. Hydrophone sensor systems are used by oil industry and the navy.

Another major use of optical fiber is in the optical gyroscope, which is used in boeing 767 aircraft and some car models for navigation purposes. Optical fibers have been put to use in illumination application; they are used as light guides in the medical filed and other areas where bright light is needed on specific targets.

The use of optical fiber span other areas of human endeavours, like in building/civil engineering, where optical fibers are used to route sunlight from the roof to other parts of the building. Optical fibers are used for decorative purposes, which include art, artificial Christmas trees and signs.

When optical fibers are doped with certain earth element, they become useful as the gain medium of a laser or optical amplifier. Also used in Endoscopy- a field of medicine for surgical or minimally invasive exploratory produces endoscopes made from bundles of fiber, which are used along with lenses to achieve the entanglement of the desired image.

5.0 FIBER OPTIC TRANSMISSION TECHNOLOGY

Optical fibers are used as media for networking and telecommunication because of their flexibility, which allows their bundling as cables. It is worthy of note that fibers can be made out of either transparent plastic or glass. The glass fibers are mainly used in long distance telecommunication applications.

The early optical fiber transmission systems operated in 850nm region at bit rates in tens of megabit per second which used mainly Light Emitting Diodes (LED's) as their light sources. The next generation saw the use of laser sources and operates in the 1300nm (for second generation fibers) and 1500nm (for the third generation fibers) region with bit rates in gigabits/second.

The spectral width of the transmitter and fiber characteristic are pivotal to the determination of the bandwidth-distance product of single mode fiber system. A single mode optical fiber can transmit signal to distances of 80 to 140km (50 to 87 miles) between regeneration of the signals. When extremely narrow, spectral laser source is used for data rates of up to about 40 gigabit per second are achievable in practice. We have a method called wavelength division multiplexing (WDM) used in increasing the bandwidth range to terabits per second (Steinke, 2002). When several wavelengths are transmitted together, wavelength division multiplexers and demultiplexers are used to combine and split the wavelength at each end of the link.

6.0 ADVANTAGES OF FIBERS OPTIC TRANSMISSION OVER COPPER/ ELECTRICAL

Fiber optic systems are important telecommunication infrastructure for world-wide broadband networks. Wide bandwidth signal transmission with low delay is a key requirement in present day applications. Optical fibers provide enormous and unsurpassed transmission bandwidth with negligible latency, and are now the transmission medium of choice for long distance and high data rate transmission in telecommunication networks.

We can say that the introduction of optic fiber has brought about reduction in the cost of digital transmission. It has also allowed a reduction in the space to house the cables. Because a signal fiber strand can carry much higher transmission rates than copper system, which means a single optical fiber cable can replace many copper wires. Optical fibers are more secure for tapping and also immune to interference and crosstalk (Hodson 2000).

Below are some of the major advantages of fiber optic cables over copper/electrical cables;

i. Less expensive- several length of optical cable can be made cheaper than equivalent lengths of copper wire.
ii. Higher data carrying capacity: since optic fibers are thinner than copper cable, therefore more fiber can be bundled into given diameter cables.
iii. Lower power consumption: it has been observed that optic fiber have lesser degradation in their signal; hence do not need high voltage like electrical transmitters. Instead, low voltage power transmitter are used which in turn saves a lot of money.
iv. Lesser signal degradation: Optical fiber signal degradation is far lesser than that experienced by copper wire.
v. Light signals: the signal transmitted by fiber optic cables is light unlike electrical signals transferred by copper wires. Light signals from one fiber do not interfere with those of other fiber in the same cable
vi. Carries mainly digital signal: they carry digital signal which has made them indispensable in computer networks.
vii. Non-flammable: since no electricity is passed through optical fiber, no fire hazard is experienced.
viii. Higher flexibility: because of the level of flexibility of optic fiber it can transmit and receive light and are used in many flexible digital cameras.

Other advantages are immunity to electromagnetic interference; including nuclear electromagnetic forces, high electrical resistance makes it safe to be used near high voltage equipment or between areas with different earth potentials (Hodson, 2000).

7.0 TESTING AND TROUBLESHOOTING OPTICAL FIBER

There are actually three distinct managers for optic fiber testing and troubleshooting tools. They enterprise network manager is the first, who has optical fiber installed in a building or campus with problems stemming from dirty and poorly made connectors and patch cords. Second is the cable contractor whose major desire would be to rapidly and accurately measure key parameters and capture them to database or a printed certification reports. Thirdly we have the managers of long-haul cable link who concerns themselves with problem emanating from broken or damaged cables (Leon-Garcia et al, 2000).

Let us now look at the first question that arises while intending to test and troubleshoot optical fibers; do we have enough light getting through to the receiver? To ascertain this, an optical Power Meter and reference light source are used to check the quality of an optical fiber link in order to begin an optical power loss measurement (sometimes characterized as ‘attenuation’ or ‘insertion’ loss): connect at light source to an optical Power Meter with a reference or ‘launch cable”; light source can typically be adjusted to levels that make measurement convenient and appropriate for a particular installation once the reference level is established by measuring the sources output power. One end of the cable being tested is connected to the launch cable and the other end to Power Meter. If certifying a cable plant is your goal, measure loss in both directions and at all relevant wavelengths. If you have many fiber and multiple wavelengths to test, used many Power Meter, upload their measurement to a PC or a printer as they are being captured. Multiple fiber could as well be tested at once and opposite direction test can be performed by reversing the connections on the meter or by changing cables in a patch panel (Leon-Garcia et al, 2000).

Another useful tool is the Fiber Optic Tracer. It could be likened to a continuity checker for copper cabling. Fiber Optic tracers produce visible light that can be seen at the other end, in fact some tracers are flashlight designed to inject light onto fiber. Another tool is visual fault locator which is like the fiber optic tracer. These devices used lesser generate visible red light at 650nm that can be seen 5km or more in a fiber. Tracer and Visual Fault locator are also very useful for gauging the quality of splices.

Rayleigh scattering, a low level backscatter phenomenon that is intrinsic to any materials that conduct light is the major cause of attenuation in optical fibers. Fiber optic connectors have small gap to prevent actual contact between fibers which could potentially lead to scratches on the surface. Once light passes from one medium to another and the index of refraction changes you get reflections. These two medium transitions in a classic fiber connector reflect about 4 percent of the optical power back towards the source which later causes and optical continuous wave reflector meter (OCWR) connects to an optical splitter or coupler that permits it to read the return loss directly.

Finally, the Optical Time Domain Reflector Meter (OTDR), is an indispensable tool when tests and measurement are to be made on optical fiber. Things such as measuring a cables length, checking distance to a backhoe misapplication and providing quantified accounts of all the splices, connectors and other events on a link. An OTDR operates like a radar system that is guided along a wire rather than radiated into space. An OTDR generates an optical pulse that travels along the fiber and gets reflected back. These reflections return at the propagation velocity characteristic of the fiber, which provides a display of reflections versus distance on the LCD screen of the OTDR.

All fiber optic cables have a typical level of inherent reflection or backscatter that shows up on the OTDR’ trace as a straight line sloping downward which indicates the attenuation of fiber over a distance. Traditional OTDR’s were heavy and require AC power making them inadequate as potable tools. The min-OTDR, which is battery powered with a size of laptop computer or smaller with LCD’s rather than CRT’s is now in common use. Vendor such as fluke-have begun combining a min-OTDR and Optical Power meter into single package, complete with various reference sources, video fiber inspection capability and software for logging, uploading and generating certification reports (Howstuffs work 2012).

8.0 CONCLUSION

This paper has summarize history and innovations, types, testing and troubleshooting of optical fiber systems. Some discussion was also done about optical transmission in comparison with copper/electrical transmission. Conclusively, we can say that the introduction of optical fiber has brought about reduction in the cost of digital transmission. It has also allowed a reduction in the space to house cables. Because a single fiber strand can carry as much higher transmission rate than copper system which mean a single optical fiber cable replaces many wires. The advancement in the fiber optic industry will greatly benefit consumers, business operators and researchers over the next few years. Powerful computing and communication foundation for the future.

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