Volume: 11 Issue: VIII Month of publication: Aug 2023

DOI: https://doi.org/10.22214/ijraset.2023.55397

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 11 Issue VIII Aug 2023- Available at www.ijraset.com

Fiber Optics: The Fundamentals, Types, Advantages and Applications

Muhammad Arif Bin Jalil
Physics Department Faculty of Science, Universiti Teknologi Malaysia, 81310 Johor Bahru, Johor, Malaysia

Abstract: This study's goal is to shed light on recent advancements and improvements in the use of optical fibre as a data transport. It offers a wealth of knowledge on the architectural design, upkeep, troubleshooting, and benefits of fibre optic transmission over copper or electrical transmission. Broadband networks all across the world depend on fibre optic lines as vital telecommunications infrastructure. Optical fibres are now the preferred transmission medium for long-distance and high data rate transmission in telecommunication networks because they offer large transmission bandwidth with hardly any latency. An overview of fibre optic communication systems is provided in this article, together with information on their architectures, important technologies and innovations, applications, types, testing, and troubleshooting.
Keywords: Fiber optic types ,transmission, , technologies ,and applications

I. INTRODUCTION

In telecommunications networks, optical fibre is frequently utilised. They are also utilised in sensors, imaging optics, and illumination. The safest and most effective way to transmit information is through optical fibre. In a number of ways, it is superior to copper cabling [4]. This article focuses on the present advantages of optical fibre cables over copper cabling for the transmission of information. In fibre optic transmission, guided media are used to transfer data. Guided transmission media, also known as bound media, uses a cable system to direct the data signals along a predetermined path. An optical fibre is a thin, transparent fibre used for transmission that is often constructed of glass or plastic.The scientific and engineering field that deals with such optical fibres is known as light fibre optics (Wikipedia, 2013). Since it has been in use for a while, fibre optic cable is replacing copper wiring as the standard. The high cost of fibre optic lines is the main barrier for users. Because of their design and architecture, they are pricey. Unlike copper cables, which transfer data using electronic impulses, optical fibres send data using pulses of modified light. It is hence immune to electromagnetic interference [5].

Numerous human pursuits use optical fibre, including lighting, microphones, sensors, imaging optics, amplifiers, and hydrophones for seismic operations. These applications have encouraged innovation in the field of fibre optics. For instance, latest developments in fibre and optical communications technology have significantly reduced signal deterioration, requiring no optical signal regeneration over distances of hundreds of kilometers.This has significantly decreased the cost of optical networking, especially over subsea distances where the performance of the entire cable system is largely dependent on the cost and dependability of repeaters [6]. Because fibre optic transmission has advantages over copper cables in long haul networks, such as larger bandwidths spanning longer distances than electrical cabling can give, we see fibre optic transmission as one of the hotly debated topic. Its advantages include extremely 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 the absence of crosstalk in situations where optical fibre cables are run alongside one another for long distances, which is a drawback.

II. TYPES OF OPTICAL FIBER

Single mode and multimode optical fibres are the two main varieties. Compared to multimode fibres, which have several pathways, single mode fibres have a smaller core. The single mode fiber's single and narrow route restricts propagation to a single and direct path, which can travel hundreds of kilometres at speeds of many gigabits per second as in Figure 1. Similarly, a multimode fibre, as shown in Figure 2, has an input ray of light that travels through numerous routes to reach the receiver. The first ray of light follows a straight path, whereas the second follows a reflected path. The difference in delay between the two pathways has been observed to generate interference between the rays; the intensity of interference is dependent on the duration of pulses, which is relative to the delays of the paths [6].Optical fibre is made up of a glass cylinder which is the core, as seen in Figures 3a and 3b, that is encircled by a concentric layer of glass (cladding). The core transmits information in the form of a flickering beam of light. When compared to the cladding, most cores have a higher optical density which is the refractive index.

A critical angle is defined by the ratio of the indices of refraction of glass. When a light ray from the core meets the cladding at an angle less than, it is entirely reflected back to the core, guiding the ray within the fibre. Attenuation is lessened when imperfections in the glass are minimised.

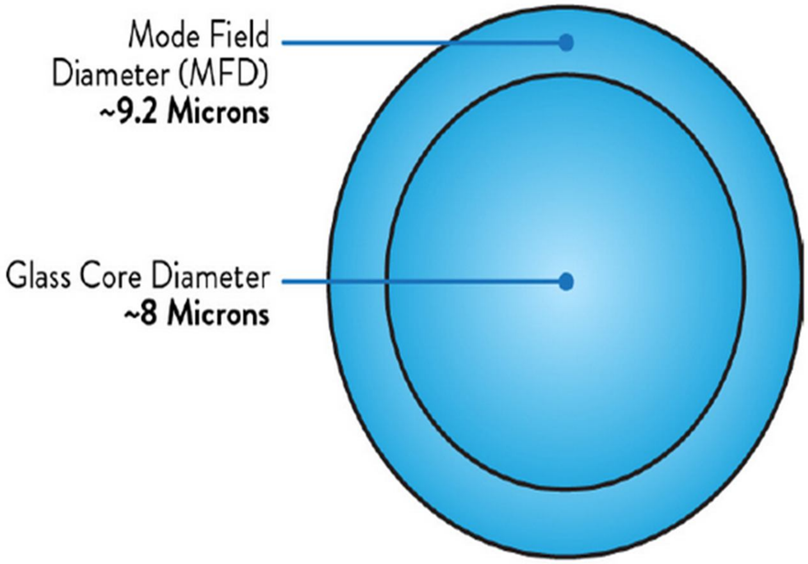


Figure 1: Standard Single-Mode Fiber [8]

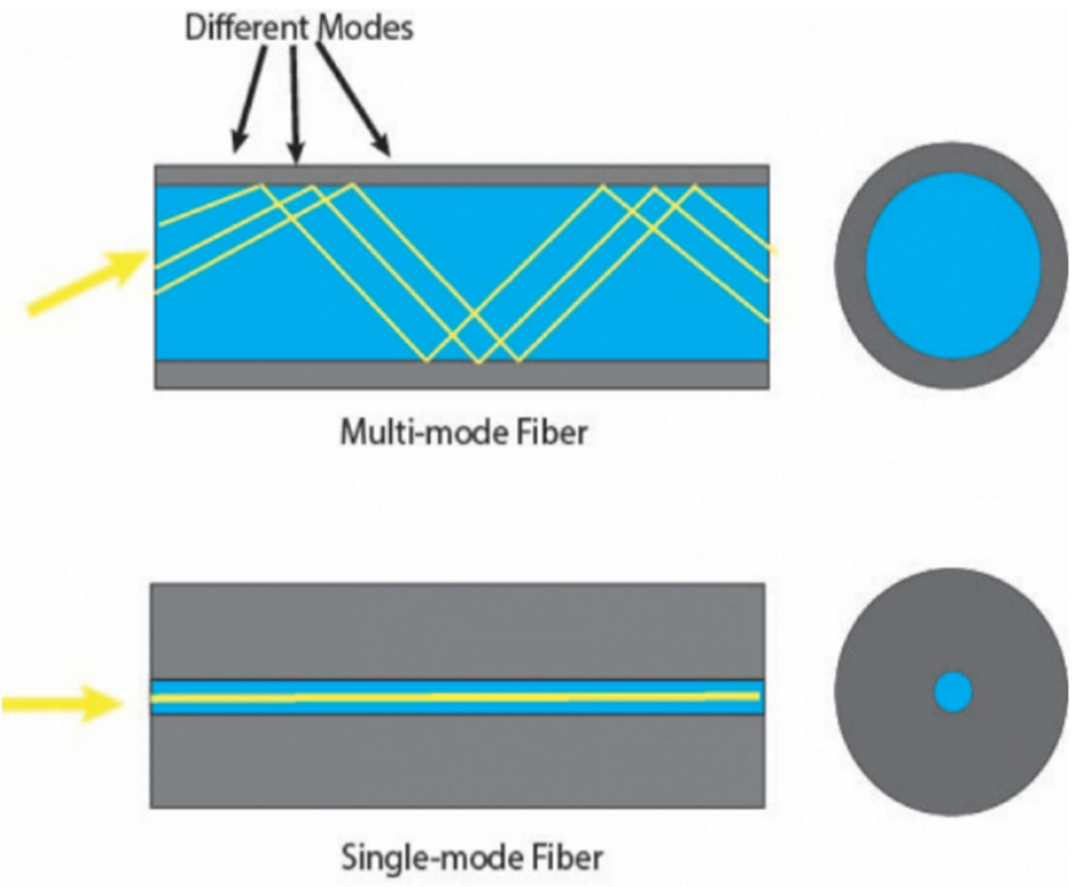


Figure 2: Multi-mode fiber versus Single-mode fiber [9]

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 11 Issue VIII Aug 2023- Available at www.ijraset.com

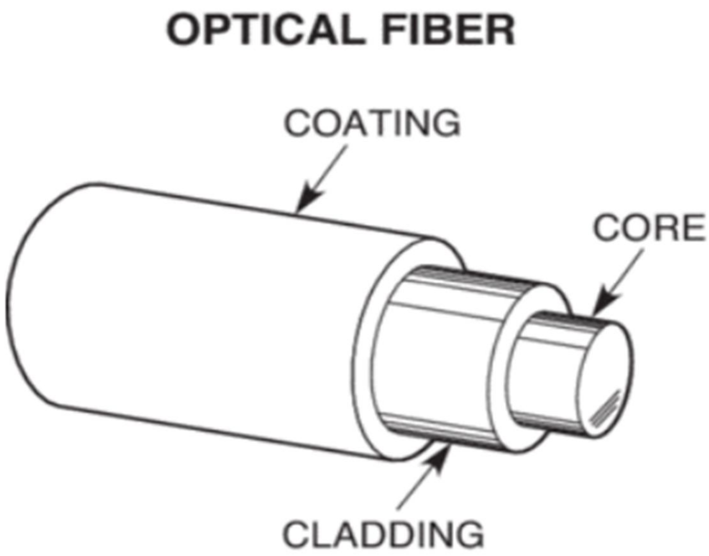


Figure 3: The cross section view of an optical fiber.[10]

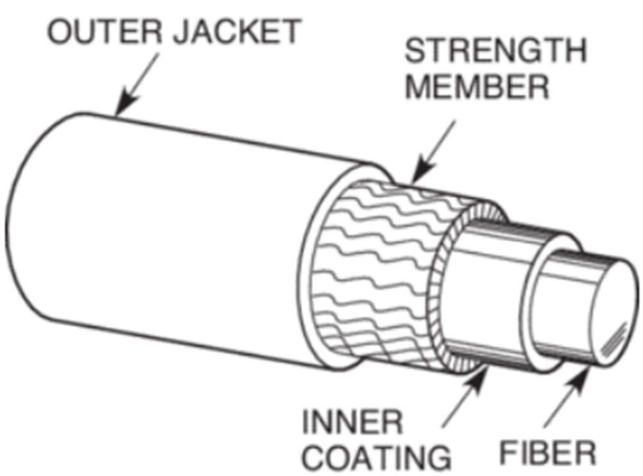


Figure 4: The cross section view of a single fiber cable.[10]

III. THE APPLICATIONS AND ADVANTAGES OF OPTICAL FIBER

Sensors made of optical fibres can monitor temperature, pressure, strum, and other characteristics. Another application of optical fibre that is employed in seismic operations is hydrophones. The oil industry and the navy both use hydrophone sensor systems.Another important application of optical fibre is in the optical gyroscope, which is used for navigation in Boeing 767 aircraft and various car types. Optical fibres have been employed in lighting applications; they are used as light guides in the medical field and other areas where intense light on specified targets is required.

Other applications of optical fibre include building or civil engineering, where optical fibres are used to transfer sunlight from the roof to other portions of the building. Decorative uses for optical fibres include paintings, artificial Christmas trees, and signs. When optical fibres are doped with a specific earth element, they can be used as a gain medium in a laser or optical amplifier. Also used in Endoscopy- a branch of medicine that develops endoscopes made of fibre bundles that are used in conjunction with lenses to achieve the entanglement of the desired image. Since of their flexibility, optical fibres are employed as media for networking and telecommunication since they can be bundled as cables. It is worth noting that fibres can be formed of either clear plastic or glass. Glass fibres are mostly utilised in long-distance telecommunications.Early optical fibre transmission systems operated in the 850nm area at data rates of tens of megabits per second, with light sources primarily consisting of Light Emitting Diodes (LEDs).

The next generation made use of laser sources and works at wavelengths of 1300nm (for second generation fibres) and 1500nm (for third generation fibres) with bitrates in gigabits/second.The estimation of the bandwidth-distance product of a single mode fibre system depends critically on the spectral width of the transmitter and fibre characteristics. Between signal regeneration, a single mode optical fibre can send signals 80 to 140 kilometres apart. In practise, data rates of up to roughly 40 gigabit per second are attainable when an extremely narrow, spectrum laser source is used. In order to increase the bandwidth range to terabits per second, we have a technique called wavelength division multiplexing (WDM) [6].When various wavelengths are sent simultaneously, wavelength division multiplexers and demultiplexers are used at each end of the network to combine and split the wavelengths. A crucial component of the global broadband networks' telecommunications backbone is fibre optic systems.

In today's applications, a wide bandwidth signal transfer with less delay is essential. Optical fibres are presently the transmission medium of choice for long distance and high data rate transmission in telecommunication networks because they offer massive and unparalleled transmission bandwidth with barely any latency. We can conclude that the development of optical fibre has resulted in a decrease in the price of digital transmission. Additionally, it has enabled a reduction in the area where the wires are kept. A single optical fibre cable can replace numerous copper wires since a signal fibre strand has substantially higher transfer rates than a copper system. Optical fibres are more resistant to interference and crosstalk and more secure for tapping [1]. Several advantages of fiber optics include Less expensive: copperwire can be created at a lower cost per foot than numerous lengths of optical cable, greater data carrying capacity: Since copper wire is thicker than optic fibres, more fibre may be bundled into cables of a given diameter, Optical fibre signal deterioration is far smaller than copper wire signal degradation, Light signals: Unlike electrical signals sent through copper lines, light signals are sent using fibre optic cables. Light signals from one fibre in the same cable do not conflict with those from another fibre, primarily carries digital signal: Since they primarily carry digital signal, computer networks cannot function without them, Since no electricity is transmitted over optical fibre, there is no fire threat, Greater flexibility: Optic fibre can transmit and receive light due to its degree of flexibility, and many flexible digital cameras employ it. Other benefits include tolerance to electromagnetic interference, especially nuclear electromagnetic forces, and high electrical resistance, making it safe to use in close proximity to high-voltage equipment or while transferring between locations with various earth potentials [1].

For testing and troubleshooting tools for optical fibres, there are actually three different managers.The enterprise network manager is the first to install optical fibre in a campus or building with issues resulting from unclean and shoddy patch cords and connectors.The second is the cable contractor, whose main goal is to quickly and precisely measure important parameters and record them in a database or printed certification reports.Thirdly, we have the long-haul cable connection managers who are concerned with issues brought on by faulty or damaged cables [1]. The Fibre Optic Tracer is yet another helpful device.It could be compared to a copper cable continuity tester. In reality, some fibre optic tracers are flashlights designed to pump light into fibre, producing visible light that can be seen at the other end. Visual defect locator, which functions similarly to a fibre optic tracer, is another technique. These less-expensive devices produce visible red light at 650 nm that may be seen in a fibre for up to 5 kilometres. In order to evaluate the calibre of splices, Tracer and Visual Fault Locator are also very helpful. The main factor for attenuation in optical fibres is Rayleigh scattering, a low level backscatter phenomena that occurs naturally in all materials that conduct light. In order to avoid real contact between the fibres, which can cause scratches on the surface, fibre optic connectors include a small gap.Reflections result from the index of refraction changing as light travels through different media. An optical continuous wave reflector metre (OCWR) is connected to an optical splitter or coupler so that it may read the return loss directly. These two media transitions in a traditional fibre link reflect around 4% of the optical power back towards the source.

Last but not least, the Optical Time Domain Reflector Metre (OTDR) is a crucial tool when testing and measuring optical fibre. Things like calculating the length of a cable, determining the distance to a backhoe error, and giving precise accounting of all the connectors, splices, and other events on a link. An OTDR functions similarly to a radar system that is directed along a wire as opposed to radiating signals into space. An optical pulse is produced by an OTDR, travels over the fibre, and is then reflected back. These reflections return at the fiber's propagation velocity, which allows the OTDR's LCD panel to display reflections as a function of distance.

Every fibre optic cable has a normal amount of built-in reflection or backscatter, which appears on the OTDR trace as a downward-sloping straight line that represents the attenuation of fibre over a distance.Traditional OTDRs weren't suitable as portable instruments since they were bulky and needed AC power. The battery-powered, laptop-sized or smaller min-OTDR, which uses LCDs rather than CRTs, is currently widely used. Vendors like Fluke have started merging an optical power metre and a minimum OTDR into a single solution that includes several reference sources, video fibre inspection capabilities, and software for logging, uploading, and generating certification reports [2].

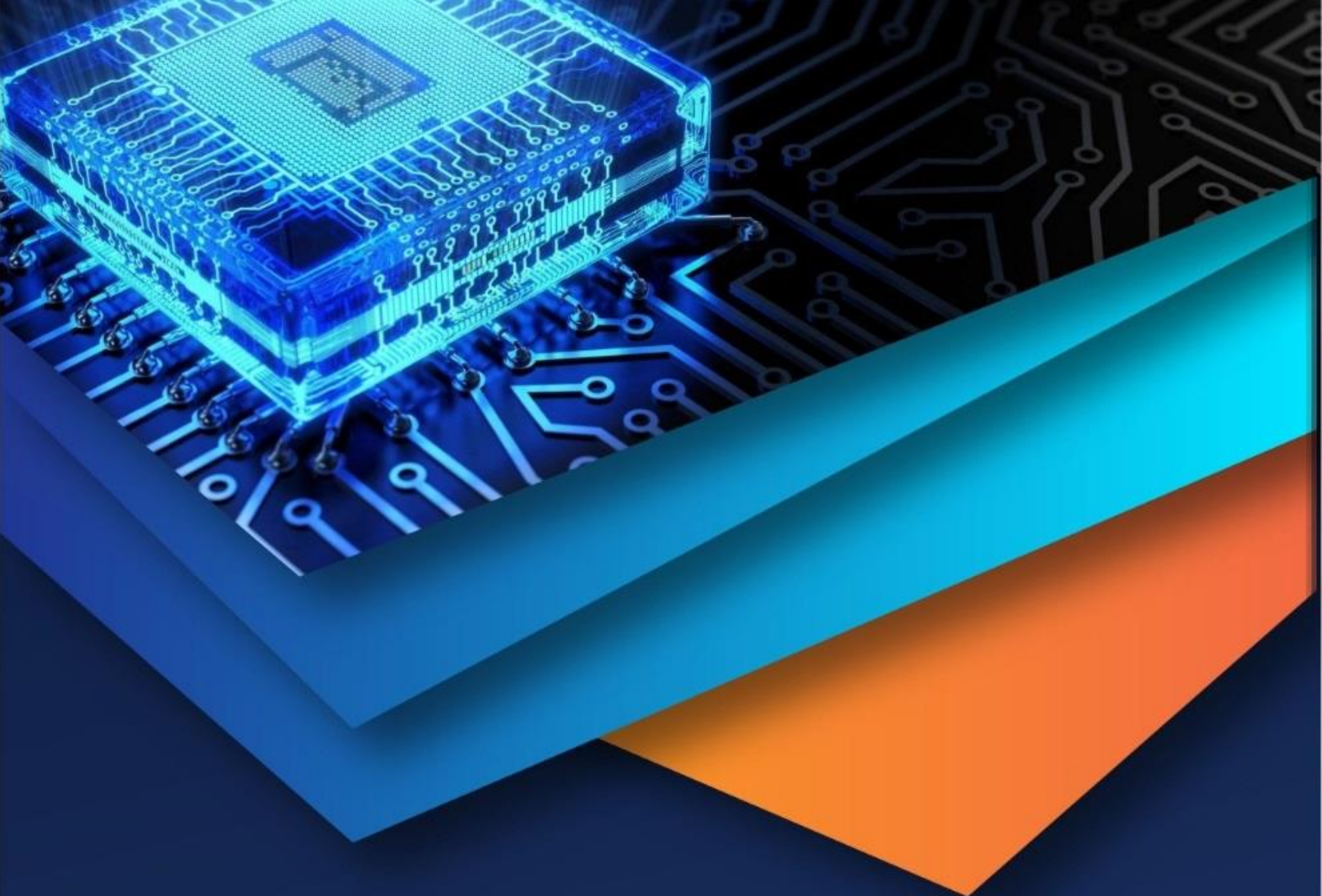
IV. CONCLUSION

This study provides a summary of the development, testing, and troubleshooting of optical fibre systems throughout history. Comparing optical transmission to copper/electrical transmission has also been discussed. In conclusion, we can state that the development of optical fibre has resulted in a decrease in the price of digital transmission. Additionally, it has made it possible to employ less space for cable housing. A single optical fibre cable can replace numerous wires since a single fibre strand has a far faster transmission rate than a copper system. Over the next few years, consumers, business owners, and researchers will considerably profit from the improvement in the fibre optic industry, the Future-proof computing and telecom infrastructure.

Let us examine the first issue that comes up while attempting to test and troubleshoot optical fibres: is there enough light reaching the receiver? In order to assess optical power loss which also known as "attenuation" or insertion loss) the quality of an optical fibre link is checked using an optical power metre and a reference light source: Connect a reference or 'launch cable' at the light source to an optical power metre; once the reference level has been established by measuring the source's output power, the light source can often be changed to levels that make measurement practical and appropriate for a specific installation. The launch cable is attached to one end of the cable under test, and the power metre is linked to the other end. You should quantify loss in both directions and at all pertinent wavelengths if you want to certify a cable facility. If you need to test a variety of wavelengths and fibres, use numerous Power Metres and upload the measurements as they are taken to a computer or printer.Multiple fibres may be checked simultaneously, and an opposite direction test could be carried out by switching the cables in a patch panel or reversing the connections on the metre [3] .

REFERENCES

[1] Hodson, P. I. (2000). Local Area Networks:Including Internetworking andInterconnection with WANs (3ed),continuum 370 Hexington Avenue, NewYork, Ch6, pp. 63-64,
[2] Howstuffs Work “how fiber optic work”retrieved on 7th of September 2012 fromURL: http” //www.electronicsshowstuffsworkswoks.com/fiber.
[3] Leon-Garcia, A. & Widjaja, I., (2000). FiberOptical Transmission, the McGraw-Hillcompany’s inc., new Yor, Ch3 pp 144-147.
[4] Noshada, M. & Rostami, A. (2012). Fwmminimization in optical communication systems using the asymmetricaldispersion managed fibers. InternationalJournal for Light and Electron Optics,vol. 123, no 9, pp758-760.
[5] Parvco, R. R. (2001). Data Communications and Networking (3rd ed.), prentice Hall,Upper saddle River, New Jersey, Ch4pp83-84.
[6] Steinke, S. (2002). Managing Fiber Cabling.Network magazine available at URLhttp://www.networkmagazine.com
[7] Wikipedia the free Encyclopedia “OpticalFiber”. Retrieved on the 3rd April 2013from URLhttp://www.en.wikipedia.org/wiki/optical fiber.
[8] https://www.ofsoptics.com/how-to-speak-fiber-geek-article-4-single-mode-fiber-geometries/
[9] https://www.lindenphotonics.com/singlemode-vs-multimode-fiber-optics-which-is-better-for-you
[10] https://www.newport.com/t/fiber-optic-basics



10.22214/IJRASET

INDEX COPERNICUS

45.98

IMPACT FACTOR: 7.129

TOGETHER WE REACH THE GOAL

IMPACT FACTOR: 7.429

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY