RP Current Trends In Applied Sciences
Vol. 2, No. 3 (July – September 2023) pp. 61–65
e-ISSN: 2583-7486

RESEARCH PLATEAU PUBLISHERS

Cite this article: J. Bhardwaj, G. Anand, S. Jindal, Prospective features of fiber optic communication and its futuristic applications, *RP Cur. Tr. Appl. Sci.* **2** (2023) 61–65.

Review Article

Prospective features of fiber optic communication and its futuristic applications

Jigyasa Bhardwaj[1], Gagan Anand[2], Shilpi Jindal[1,*]
[1]Department of Physics, University Institute of Sciences, Chandigarh University, Gharuan, Mohali – 140413, Punjab, India
[2]Applied Science Cluster, School of Engineering, University of Petroleum & Energy Studies, Dehradun – 248001, Uttrakhand, India
*Corresponding author, E-mail: shilpi.uis@cumail.in

ARTICLE HISTORY
Received: 20 July 2023
Revised: 29 August 2023
Accepted: 30 August 2023
Published online: 16 Sept. 2023

KEYWORDS
Fiber optics; Transmission of data; Communication purposes.

ABSTRACT
Fiber optic communication is indeed a promising trend of the future with its numerous applications and advantages. The use of fiber optics allows for the transmission of data over long distances with minimal loss in signal quality. This makes it ideal for both individual and military applications. One of the key benefits of fiber optics communication is its high speed of data transmission. Unlike traditional copper wire cables, fiber optics can transmit data at speeds that are almost at the speed of light. This makes it ideal for high bandwidth applications such as video conferencing, online gaming, and streaming. Another significant advantage of fiber optics is its reliability. Fiber optic cables are less susceptible to damage from environmental factors such as moisture, temperature changes, and electromagnetic interference. They are also less prone to signal interference from nearby cables, making them ideal for use in densely populated areas. Moreover, fiber optic cables are lightweight and flexible, making them easy to install and maintain. They also have a longer lifespan than copper cables and require less maintenance, resulting in cost savings over the long term. To optimize the use of fiber optics communication, it is recommended to use high-quality fiber optic cables and equipment. Regular maintenance and testing of the cables and equipment can help to identify and resolve any issues before they escalate. Fiber optics communication is a reliable, high-speed, and efficient means of transmitting data. In this review we emphasize on high-quality equipment and regular maintenance, the benefits of fiber optics in a wide range of applications.

1. Introduction

Fiber optic communications are increasing in demand with the high service and low cost of maintenance associated with it. In addition to this, the commercial demand for this product has been on a steady increase with the telecommunication capacity that is the main service offered along with the Internet services. The advancement in technology has enabled individuals in conveying more data through optical fiber regarding long distances. The most desirable feature of this optical network is the ability to process information from the domain for amplification purposes. It helps in transferring data at an efficient rate that can reduce and resolve many issues for communication purposes. However, with the benefits of optical fiber in communication, there are still certain improvements that are needed to be done. Communication in the future is desired to be there to be more dependable and robust than in the present moment. Nevertheless, it can be justified that using fiber optics in transferring data and communication purposes has resolved many of the issues faced earlier. This research paper focuses on the benefits as well as drawbacks of fiber optics in communication.

2. Objectives

1. To investigate the current state-of-the-art in fiber optic communication.
2. To explore the prospective features of fiber optic communication.
3. To assess the advantages and limitations of fiber optic communication.

3. Literature review

Fiber Optic Communication has been widely adopted in various industries due to its significant advantages over traditional communication technologies. The future of fiber optic communication looks promising, with several new developments and applications being explored. In this section, we will discuss the prospective features of fiber optic communication and its futuristic applications.

3.1 Prospective features of fiber optic communication

Increased bandwidth: The demand for higher bandwidth is increasing rapidly due to the emergence of new technologies such as Artificial Intelligence (AI), Augmented Reality (AR), and Virtual Reality (VR). Fiber optic communication can meet this demand by providing high-speed data transmission at a lower cost. With the development of new technologies, the bandwidth requirement is expected to increase further in the future, and fiber optic communication is likely to play a critical role in meeting this demand.

Enhanced security: Fiber optic communication is highly secure compared to traditional communication technologies,

such as copper wires or radio waves. The data transmitted through fiber optic cables is difficult to intercept, and any attempt to do so would cause a significant loss of signal strength. In the future, fiber optic communication is likely to become even more secure with the development of new encryption technologies.

Low power consumption: Fiber optic communication requires less power compared to traditional communication technologies. This is because fiber optic cables do not require signal repeaters, which consume a significant amount of power. With the increasing focus on energy efficiency, fiber optic communication is likely to gain more popularity in the future.

High reliability: Fiber optic communication is highly reliable due to its immunity to electromagnetic interference, corrosion, and other environmental factors. This makes fiber optic communication suitable for use in harsh environments such as oil rigs, mines, and offshore platforms. In the future, fiber optic communication is likely to become even more reliable with the development of new materials and technologies.

Optical communication networks: All the fiber communication optics have been envisioned in completing the optical domain which will give rise to the communication network which can transfer data within seconds. This would recognize the communication industry that the signals will be processed through this optical domain without the electrical manipulation involved. In the present time, the process of switching signals and processing them takes place along the electrical domain that is to be converted into a signal before it can be sent out [3]. After processing and routing the signals these are then converted to optical signals and transferred to long distances. This process results in latency over the network and a barrier is placed for the user in the achievement of high data. One of the vital benefits of using optical networks is that there are no requirements in replacing the electronics within the electronics when there is an increase in data rate as the processing signal as well as routing is through the optical domain [15]. This saves up a lot of time and can reduce the latency for the user.

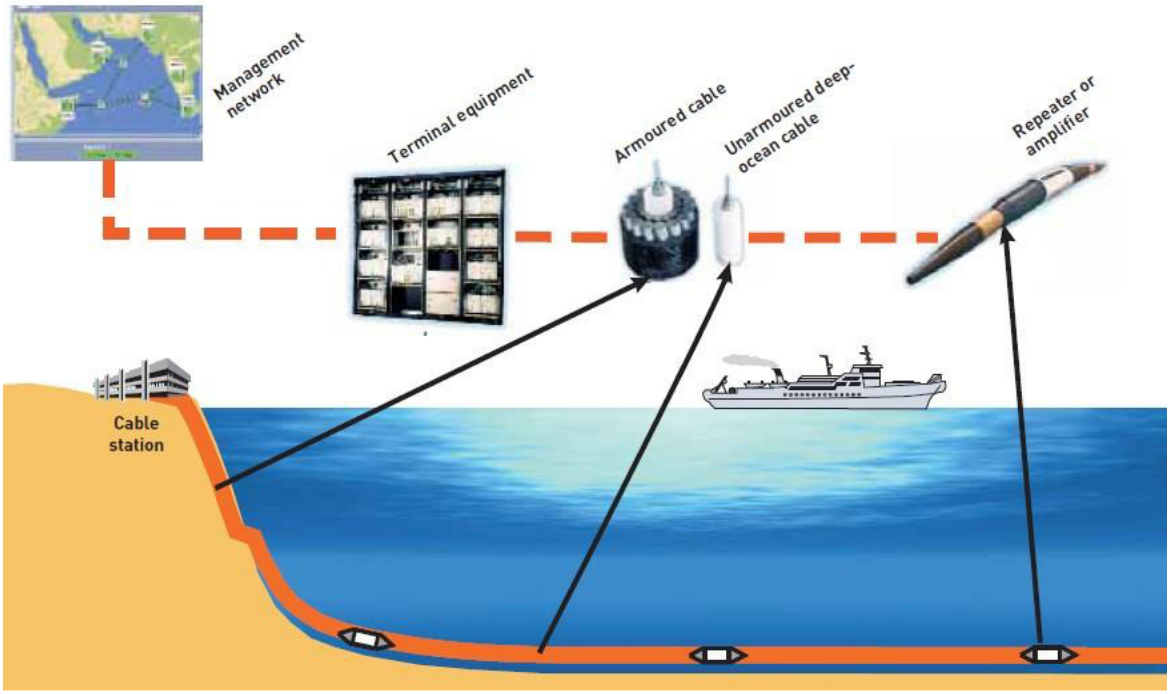

Figure 1: Submariner cable system (Source: Hamza *et al.,* 2018)

3.2 Usage of optical fiber in other innovations

The optical domain will also be trending in the future along with the extension of semiconductor lasers. These lasers are shorter in wavelength and have high output which acquires the interest of optical applicants. At present, the sources of this laser are spectrally shaped with the jerk managing in compensating the chromatic dispersion. As a result of this, the firing pulls impulse and the chromatic dispersion is reduced [2]. New instruments for this development are to be characterized by single-mode lasers that can hold great importance in the future. Coherent optical systems are also beneficial for the single longitudinal node that you know is useful for turning different frequencies. In addition to this, polymer optical fiber also has certain benefits in the data communication industry [13]. The usage of glass fiber and copper current copper cables is backdated as the glass optical fibers incur less manufacturing costs and give more productivity.

3.3 Usage of optical fiber in submarine cables

For increasing the flexibility in network configuration optical fibers have been installed in submarine communications. This has been developed with keeping in mind the configuration regarding the mesh network which is the vital step in making the right direction. With the ring network joining the station the single ring is connected directly

to the main frame [11]. The large-scale optical system has adopted this configuration by multiplexing the technology and branching out the signal regarding the wavelength domain [6]. In addition to this, the misconfiguration is also interconnected with the mainframe station which adds more stability and efficiency to transferring the data. This has been of great help with efficiently managing the ongoing data traffic and dynamically changing the changing preferences [7]. The trend is to continue regarding the breakthroughs in the future and has been extending a practical deployment for the new generation optical fibers.

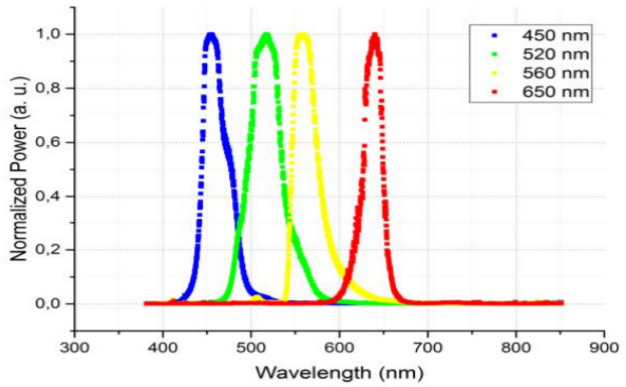

Figure 2: Different LEDs used in optical fiber (Source: Sampaio *et al.,* 2018).

4. Materials and methods

In the study, the selection of appropriate materials plays a crucial role in determining the performance, reliability, and overall effectiveness of optical fiber. This section explores the key materials used in optical fiber and explains why they are chosen for this groundbreaking technology.

Core material: The core of an optical fiber is the central region through which light signals propagate. It is typically made of high-purity silica glass or sometimes other materials, such as plastic or compound semiconductors. Silica glass is the most widely used core material due to several reasons:

1. *High Refractive Index:* Silica glass possesses a high refractive index, allowing efficient light transmission by confining the light within the core and enabling low signal loss during propagation.
2. *Low Attenuation:* Silica glass exhibits low attenuation, meaning that it minimizes the loss of light energy during transmission, resulting in longer transmission distances.
3. *Thermal Stability:* Silica glass has excellent thermal stability, ensuring that the optical fiber can withstand high temperatures without compromising its optical performance.
4. *Compatibility:* Silica glass is chemically inert and non-reactive, making it compatible with various environments and allowing for the transmission of light signals across different applications.

Cladding material: The cladding surrounds the core of the optical fiber, providing a lower refractive index medium that confines the light within the core. It is typically made of a different type of glass or a polymer material. The selection of cladding materials is based on the following factors:

1. *Refractive Index Difference:* The cladding material must have a lower refractive index than the core material to facilitate total internal reflection and ensure efficient light transmission within the core.
2. *Mechanical Strength:* The cladding material should possess adequate mechanical strength to protect the delicate core and maintain the integrity of the fiber during handling, installation, and operation.
3. *Compatibility:* Similar to the core material, the cladding material should be chemically compatible with the environment in which the optical fiber will be deployed.

Coating material: The coating layer is applied over the cladding to protect the fiber from external factors such as moisture, mechanical stress, and temperature fluctuations. The coating material is usually a polymer, such as acrylate or polyimide, chosen for the following reasons:

1. *Mechanical Protection:* The coating provides a physical barrier to shield the fiber from damage due to bending, abrasion, or other external forces, enhancing its durability and lifespan.
2. *Flexibility:* Polymer coatings offer flexibility, allowing the optical fiber to be easily bent and routed without impairing its optical performance.
3. *Dielectric Properties:* The coating material must have excellent electrical insulation properties to prevent any interference with the optical signals being transmitted through the fiber.
4. *Environmental Resistance:* The coating material should be resistant to moisture, chemicals, and other environmental factors that may degrade the fiber's performance.

The choice of materials in fiber optic communication is critical to achieving high-speed, low-loss, and reliable data transmission [14]. Silica glass for the core, along with suitable cladding and coating materials, ensures efficient light confinement, low attenuation, mechanical protection, and environmental stability [12]. These material properties contribute to the futuristic applications of fiber optic communication, enabling advancements in telecommunications, data transmission, and other emerging technologies [8].

The main source of information for this research is of secondary nature that is the journals by different authors which gives a better perspective of optical fiber communication. It also gives us a better understanding of the use of this optical fiber in different industries and the benefits and drawbacks associated with it. In the present scenario, many new companies are adopting optical fibers for the transfer of their data in the international market segment [10]. These optical fibers are ever-evolving and the growth which is experienced by this industry is profitable.

5. Discussion

Optical fiber is the communication technology which uses pulses of light in transferring information from one source to another through the medium of a wire or fiber connected. The main information transmitted is transitioned into a digital basis with the use of telephone systems and computer systems. These are cylindrical waveguides which are manufactured from low materials like silicon dioxide from the main core of the fiber [1]. The core of this fiber comprises the refractive

index which is higher than the outer medium and the purposes of light are then transferred from the access with the process of internal reflection. This communication system is an essential system carried out by the transmitter which converts the electrical signal into an optical one. It makes the data more preserved and quick in order to transform from one point to another [4]. The several bundles regarding the optical fiber are as in the cable which then boosts up the amplifiers to power the signal and the receiver, on the other hand, converts this and converts it back to the original transmitter.

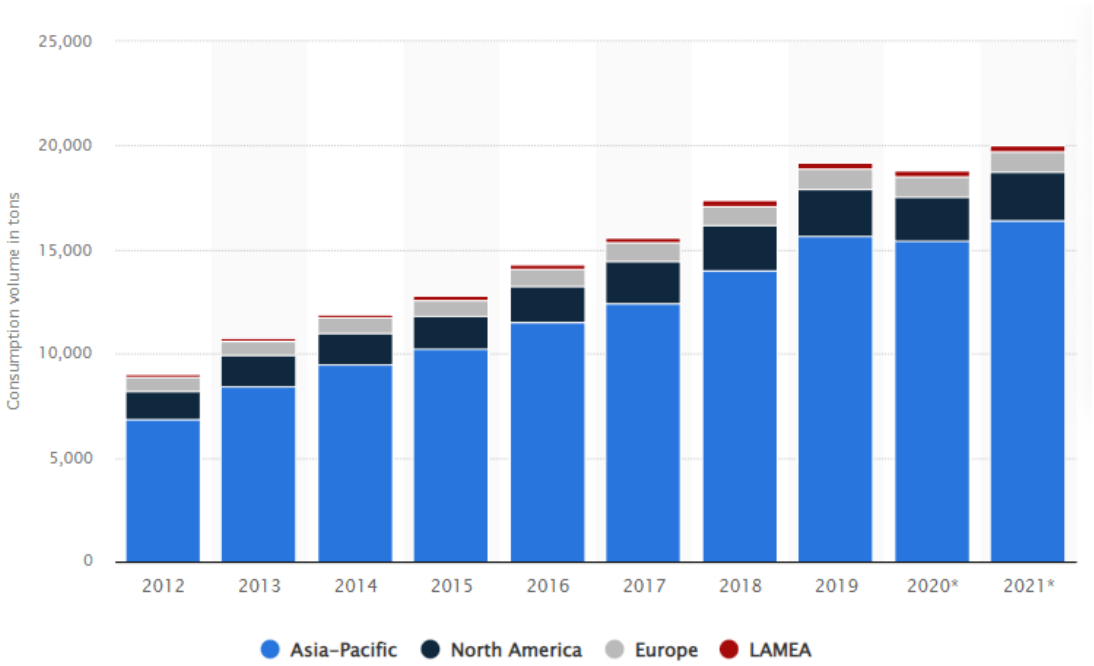

Figure 3: Global consumption of Fibre Optic (Source: Statista, 2022)

The benefits of this optical fiber are higher than the drawbacks however there are certain introductory and investment costs related to the use of these optical fibers. Fiber optics are the communication media which is definitely in the future of communication for data. The evolution of these optics regarding communication has been channeled by the advancement in industries and the increased demand for communication. It has been evident that the continuing of this trend in the future will be with more advanced technological means. The long haul for the optical transmission in this is the main limitation which is imposed due to the floors of the transmission medium [5]. The cancellation in dispersion effect the researchers have prompted in studying the benefits of solicitation. The propagation of this has interacted with more understanding regarding the electromagnetic light and the medium used for transmission which is the main necessary for comments meant of this infrastructure. The light pulse which is used to propagate this is the main understanding of it. The optical transmitter and receiver are to have certain improvements that can achieve better quality transmission signals with reduced waveforms. The excellence in chromatic dispersion along with optical signal is the best suitable for the long hall system for communication. Henceforth it can be said that optical fiber communication signals are a trend of the future but certain amendments need to be done in order to get the best of it.

6. Futuristic applications of fiber optic communication

Quantum communication: Quantum communication is a new field of communication technology that uses quantum mechanics principles to provide high-security communication. Fiber optic communication is a critical component of quantum communication, and it is likely to play a crucial role in its future development. Quantum communication is expected to be used in various applications such as secure banking, military communication, and government communication.

5G Communication: 5G communication is the next-generation wireless communication technology that aims to provide higher bandwidth, low latency, and improved reliability. Fiber optic communication is expected to play a critical role in 5G communication by providing high-speed backhaul and fronthaul links. 5G communication is expected to be used in various applications such as autonomous vehicles, smart cities, and Internet of Things (IoT) devices.

Space communication: Space communication is a critical application that requires high-speed data transmission over long distances. Fiber optic communication is likely to play a crucial role in space communication by providing high-speed data transmission over long distances. The use of fiber optic communication in space is expected to increase in the future, as space exploration and communication technologies continue to evolve.

Smart grid communication: Smart Grid communication is a new field of communication technology that aims to improve the efficiency and reliability of the electric grid. Fiber optic communication is likely to play a critical role in smart grid communication by providing high-speed data transmission and improved reliability. Smart Grid communication is expected to be used in various applications such as renewable energy integration, demand response, and grid automation.

7. Recommendation and conclusions

The fiber optics communication system has been developed as an integral network to channel and transfer data from one point to another [9]. However, there are certain flaws regarding the optical transmitter and receiver of the signal core.

1. The main frame of the signal further needs to be addressed so as to regulate more data traffic and monitor the users optimizing this data.
2. The inner walls of the fiber optics need to be more elongated so that the data incoming this traffic can be greater in quantity.
3. The wavelength range of this technology can be driven up by the extension and developments in filtering technology.

Fiber optics communication has helped mankind greatly in the transmission of data from one point to another regardless of the distance. In addition to this fibers are channeled all across the group in order to transmit data from the source and many big Tech companies have invested a lot in it. The miniaturization of the fiber used in this optical communication can be one of the major trends which affects the data industry in the future. Though having so much potential this system needs certain amendments to the mainframe which can create more opportunities for it. Also, Fiber optic communication has transformed the telecommunication industry by providing higher bandwidth, increased transmission capacity, and improved reliability. The future of fiber optic communication looks promising, with several new developments and applications being explored. Prospective features of fiber optic communication include increased bandwidth, enhanced security, low power consumption, and high reliability.

References

[1] J.P. Zhang, C. Liu, Y. Jiang, C. Zhang, W.J. Han, Z.Y. Ma, S.Z. Hu, X.L. Li, Fiber linking two distant metropolitan areas, *Nature Photon.* **15** (2023) 570-575.

[2] I. Floris, J.M. Adam, P.A. Calderón, S. Sales, Fiber optic shape sensors: a comprehensive review, *Opt. Lasers Eng.* **139** (2021) 106508.

[3] A.S. Hamza, J.S. Deogun, D.R. Alexander, Classification framework for free space optical communication links and systems, *IEEE Commun. Surv. Tutor.* **21** (2018) 1346-1382.

[4] E. Hooda, J. Gupta, Technological Trends in Optical Fibre Communication (2018).

[5] S. Korposh, S.W. James, S.W. Lee, R.P. Tatam, Tapered optical fiber sensors: current trends and future perspectives, *Sensors* **19** (2019) 2294.

[6] H. Matsumoto, E. Araki, T. Kimura, G. Fujie, K. Shiraishi, T. Tonegawa, K. Obama, R. Arai, Y. Kaiho, Y. Nakamura, T. Yokobiki, Detection of hydroacoustic signals on a fiber-optic submarine cable, *Sci. Rep.* **11** (2021) 1-12.

[7] F.A.N. Sampaio, V.N. Silva, L.A. Neto, T.N. Ferreira, A.P.L. Barbero, R.M. Ribeiro, Highly spectrally efficient discrete multi-tone transmission over step index PMMA optical fiber for short-range optical communication, *J. Commun. Info. Syst.* **33** (2018).

[8] Statista, *Fiber optic perform consumption volume by region 2012-2021*. [online] Available at: https://www.statista.com/statistics/1137222/fiber-optic-preform-consumption-volume-by-region/ (Accessed: 1 November 2022).

[9] N.H. Wong, A.S. Tong, M.T. Posner, Modular and extensible lesson on optical fiber communication for youths, *Phys. Edu.* **54** (2019) 055004.

[10] G.B. Xavier, G. Lima, Quantum information processing with space-division multiplexing optical fibers, *Commun. Phys.* **3** (2020) 1-11.

[11] K. Zhong, X. Zhou, J. Huo, C. Yu, C. Lu, A.P.T. Lau, Digital signal processing for short-reach optical communications: a review of current technologies and future trends, *J. Lightwave Technol.* **36** (2018) 377-400.

[12] F.N. Khan, Q. Fan, C. Lu, A.P.T. Lau, An optical communication's perspective on machine learning and its applications, *J. Lightwave Technol.* **37** (2019) 493-516.

[13] S. Korposh, S.W. James, S.W. Lee, R.P. Tatam, Tapered optical fibre sensors: current trends and future perspectives, *Sensors* **19** (2019) 2294.

[14] D. Tosi, Review of chirped fiber Bragg grating (CFBG) fiber-optic sensors and their applications, *Sensors* **18** (2019) 2147.