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FUTURE TRENDS IN OPTICAL WIRELESS COMMUNICATIONS SYSTEMS: REVIEW

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Abstract.

Optical fibers are frequently used in data transmission systems, Because of their ability to transmit large amounts of information and dielectric nature. In central, metropolitan, or broad-area applications, network topologies incorporating many wavelengths per optical fiber are utilized to connect thousands of users with a wide variety of transmission rates and capacities. The simultaneous transmission of many wavelengths over a fiber with a nm range of 1300 to 1600 is a potent characteristic of an optical communication network. Wavelength division multiplexing (WDM) is a method for combining various wavelengths onto a single fiber. The WDM concept, when combined with optical amplifiers, produces communication lines that enable quick communication between users across national borders. An overview of the difficulties with fiber-optic communication is provided in this paper. The areas that will be most important for the development of optical communications in the future are outlined in this study. Modern optical fibers and integrated optics were both developed in the dominion of optical machinery and parts. Optical fiber communication systems are widely used for high-speed data transmission over long distances. There are some specific details and examples of optical fiber communication systems such as Fiber Optic Cables, Light Sources, optical modulator, optical amplifier, optical receivers, fiber optical network, medical applications.

Keywords: Optical fiber communication system; benefit; drawbacks; free space optics.

1.Introduction

An important piece of the global broadband network infrastructure is the optic fiber communication system [1]. Massive and distinctive transmission bandwidth is offered by optical fibers with little perceptible delay. It is currently the transmission method of choice for long-distance transmission [2]. Some of the desirable qualities, such the high and quickly rising consumer and commercial interest in the restricted transmission of media, are the driving force behind the widespread acceptance and use of fiber optic communications [3,4]. Fiber optics serve as the foundation of the telecommunications infrastructure and are perfect for gigabit transmission due to their characteristics [5]. Global demand for high data rates is rising, thus researchers are looking for other ways to supply gigabit capacity [6,7].

There are several sorts of optical communication networks [8]. For instance, the most current optical signal technique-based code division multiple access networks [9]. LI [10] provides a thorough review of the security aspects of the OICl physical layer.

In this article, a thorough analysis of the most recent and effective solutions to the problems associated with optical fiber communication is undertaken. Higher open and collaborative standards are needed for optical fiber communication and transmission network systems to be reliable. Additionally, a summary is provided of the specifics of their approach, including the use of datasets, optical instruments, and the conclusions reached. Additionally, we highlighted the techniques that produced the best accuracy rates as well as the most popular ways.

The scientific question addressed in this work is whether optically coupled connections may overcome the so-called "fiber wall"—a physical barrier—from a single optical fiber. Rapid technical research is expected to reach a stage when systems using standard single-mode optical fiber that currently permit expanding transmitting capacity will no longer be possible to enhance the bandwidth of the optical link using a single optical fiber. Scientific endeavors are much more required in light of this "fiber wall" disaster to develop potential answers. In order to accomplish the goals, current networking systems include coherent communications, multidimensional modulation, and multiplexing technologies, as well as optical signal processing.

Future high-performance fiber lines in the backbone to wideband user connectivity in our homes will be made possible by adaptive wavelength, bandwidth, and modulation formats made possible by current optical networking. Declaring the deployment of optical fiber communications networks in the future is the main objective of this paper, or its contribution. This implies that huge amounts of data may be transported utilizing simple, affordable, and energy-efficient technologies.

The organization of the remaining paper is as follows: The research is concluded in portion 4, which is the concluding portion. Section 2 presents a theory of optical fiber communications issues and devices. Section 3 presents a related work on optical fiber communications challenges.

1.1 Optical network devices

Planar light wave circuits (PLCs) are an integrated optics path in which the optical communication industry is developing [11]. The integration turns into a crucial instrument that aids in lowering the cost of manufacturing optical devices, reducing the quantity of carbon emissions that result from power consumption, and improving the operation of telecommunications networks. The evolution of optical

circuits suggests that the existing hybrid systems will be replaced by less expensive monolithic ones [12].

In a single box, hybrid integrated circuits and their present technology combine several discrete or integrated circuits that carry out certain electrical and optical activities [14].

The goal of contemporary research is to combine light sources, modulators, transmitters, and signal processing components "(and vice versa; detectors, demodulators, and receivers)". Free-Space Optics (FSO), Micro-Electro-Mechanical Systems (MEMS), photonic crystals, gratings, plasmonic circuits, ring resonators, and devices are some of the emerging optical devices [15].

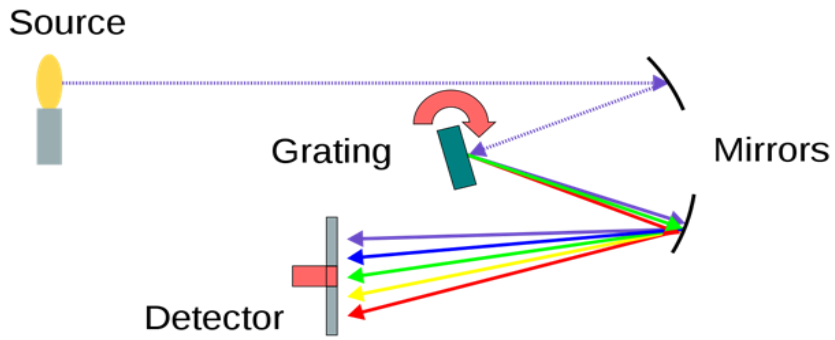

Figure 1. Polarization Measured Directly by Optical Equipment [13]

1.2 Fibre Optics communication principles

Digital information is exchanged between two sites via fiber-optic communication, which uses light waves to travel over an optical fiber [16]. Digital information refers to the type of data transferred across computer and internet networks. Dielectric waveguide cylinders comprised of silicon dioxide materials make up the optical fiber. An optical transmitter that uses optical fiber is used to convert electrical signals into optical signals [17]. The cable includes a number of optical fiber packages, an optical receiver to convert the received optical signal back to the electrical signal that was originally delivered, and optical amplifiers to increase the strength of the optical signal. A simplified model of the fiber optic communication system is shown in Fig. (1) [2].

One of the optical methods with the highest potential is Surface Plasma Resonance (SPR), which has several applications. In 1983, SPR technology was first used with sensors. Since then, a number of SPR sensing structures have been discovered for chemical and biological sensing [12]. With a transverse magnetic field or p-polarized light, SPR technology causes electron density oscillations on the metal-dielectric interface (referred to as a plasma wave barrier, or SPW) [18].

The fundamental steps in the fiber optic communication process are:

i) The optical signal is produced by the transmitter using an electrical signal.

ii) The second stage is transmitting the signal together with the fiber to protect it from distortion.

iii) Receiving the sent optical signal makes up the third stage. iv) The optical signal is then transformed into an electrical form as the last stage.

1.3 Benefits of optical fiber communication systems

i)Huge possible bandwidth: the metallic cables have less potential transmission BW than the optical carrier frequency.

ii) The small weight and size: a small diameter is one of the optical fiber characteristics. iii) Isolation of electrical: the fabrication of optical fiber is either from a plastic polymer or glass. These are electrical insulators, and it does not exhibit earth loop or interface problems; this is unlike their metallic counterpart. iv) The security of signal: The high degree of protection of the signals is achieved because the optical fiber's light does not radiate significantly.

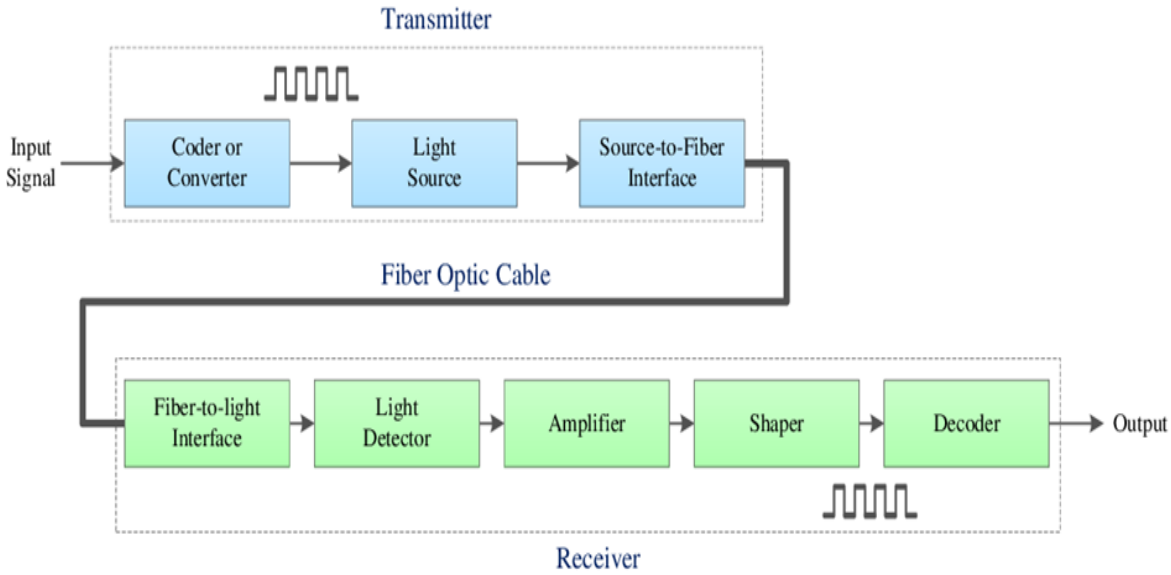

Figure 2. Communication Systems of Fiber Optic

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The loss transmission is low: The optical fiber technological developments have resulted in the optical cables in the last years.

1.4 Disadvantages of optical fibre communication systems

i) Huge potential bandwidth: The optical carrier frequency has a greater potential BW for transmission than do metallic wires.

ii) The lightweight and tiny size: One feature of optical fibers is their small diameter. iii) Electrical isolation: Glass or plastic polymers are used to make optical fibers, depending on the application. Contrary to their metallic equivalent, they are electrical insulators and do not have earth loop or interface issues. iv) Signal security: The fact that the optical fiber's light doesn't radiate much allows for a high level of signal security.

The transmission loss is minimal: The technical advancements in optical fiber have led to optical cables in recent years.

1.5 Fibre optical communications future trends

1.5.1 *Technological advancements in optical transmitter and receiver*

In fiber-optic communications, attaining a good transmission quality is crucial due to the optical signals' distorted waveform and poor signal-to-noise ratio during transmission.

The goal of the study is to embrace innovative and cutting-edge modulation technology by creating optical transceivers. In addition to stronger error correction codes, optical signal to noise ratio (OSNR) tolerance and chromatic dispersion will be useful for "ultra-long-haul" communication systems.

1.5.1 *Complete networks of optical communication*

In order to facilitate the expansion of the entire optical communication network, fiber optic communications are envisaged in the optical domain. Such networks will handle all signals in the optical domain, but they will externally manipulate electrical forms [21]. The advantage of whole-optical networks is that since all routing and signal processing processes take place in the optical domain, there won't be a need to replace the electronic as the data rate grows [2].

1.5.1 A summery of recent improvements of optical fiber communication system

Networks for information transmission and fiber-optic networking are undergoing fast technical change [23]. As a result, this section showcases upcoming projects that are connected to the topic of difficulties in fiber optic communications.

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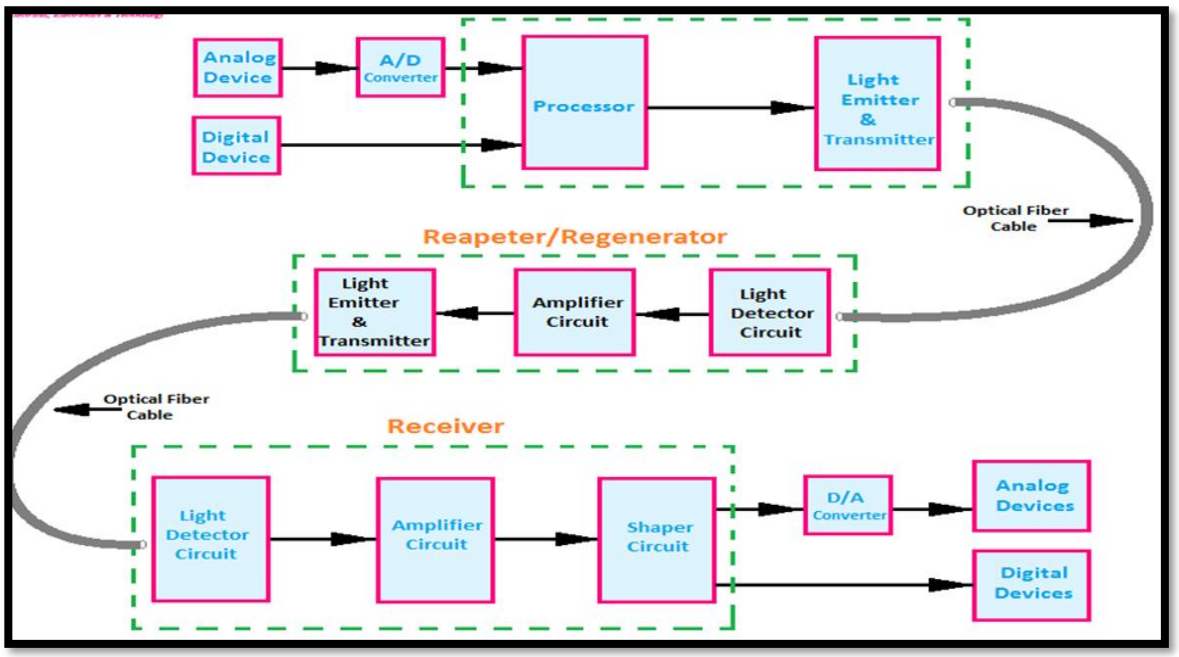

Fig. 3. Schematic of an optical communication network [22]

In article [24], the optical intersatellite is utilized to discuss optical communication technologies, theoretical investigation, and actual field trials. The usage of orbit-to-ground links is therefore possible [25,26]. Finally, terminals are compact and lightweight. Researchers in [27] examined applications for optical fiber biosensors and identified patterns in actual samples for the biosensors. [28] illustrates flexible transducers' optimization and characteristics. [29] illustrates the developments in fiber optic sensors based on immobilized nitrophenol. In research, the optical affinity sensor was introduced [30]. Researchers report the first experimental demonstration of fiber-based wavelength division multiplexed data in [31].

1.9 Processing Time

Large backbone networks are currently crucial in particular because of the increase in network traffic, notably data transmission traffic brought on by the development of cloud-based and video streaming systems [32]. With the use of digital signal processing (DSP) and digital coherent optical communication, the wavelength-division multiplexing (WDM) capabilities of optical communication systems may be greatly increased [33]. A useful and accurate fiber delay measuring tool has emerged[34]. The fundamental concept is to convert the time fiber transmission delay into phase detection, remove uncertainty by frequency scanning, and then obtain the result using a data processor [35].

The time-regulated digital optical frequency domain reflectometry-based fiber-optic fiber sensor provides a linear response to long measuring wavelength vibration signals. However, implementing

online data processing is challenging due to computational complexity and a significant volume of data stream [36].

It is important to maintain track of the Life-Cycles (LC) of processes and threads as they go from the formation of a new process through termination (or even starvation) [37]. Users are unaware of what transpired while the software was running. This could be the norm for non-programmers [38]. However, if programmers understood the precise sequence of events for a program, the program's structure may eliminate various complications for processes and states [39]. They are able to alter the process's states and programming strategy since they are aware of what is occurring right away [40]. As a result, the system may be enhanced.

Long periods of time are required to tackle complex problems with low dependability and consistency. In order to address these issues, studies have divided the issue into discrete parts and addressed each one independently so that each processing unit may work on its component of the issue simultaneously with the others [41].

Multiprocessor setups are used in the design of contemporary computer systems [42]. The simultaneous execution of many threads on various processors is made possible by the presence of multiple processors (multiple threads) [43]. Concepts of parallel processing are the main impacts of pushing processes in shared memory structures. The CPU and total computing times are influenced by these influences. CPU utilization is frequently determined differently depending on the amount of the loading and the number of CPUs [44].

One of the most important processing speed patterns to boost performance is multi-core [45]. Therefore, the focus of the new manufacturers is on multi-core processors (MCP). One of the numerous benefits of MCP is that it enhances computer multitasking abilities [46]. Instead of one full implementing core with a separate front-side bus interface, these processors have numerous them [47].

The concurrent execution of several threads can significantly increase the performance and overall efficacy of computer systems [48]. Different computer systems come with a variety of performance counters [49]. The number of active threads may be monitored via performance counters, for example [50].

Recent growth in Internet and wireless network users has raised the requirement for encryption techniques and tools to protect user data sharing over an unsecured network [51]. These characteristics allow for the use of data security, integrity, and verification. For the encryption of internet communication, symmetrical block chips are essential [52].

The partitioning of the simulation models among the various execution units is a prerequisite for parallel and distributed simulation (PADS) [53]. A portion of the model is owned by each of them. In other words, each PADS is fully local because it is dealing with its own local event list [54]. However, delivering locally generated events to remote execution units may be necessary, which might reduce the run time expense and increase the efficiency of the model [55].

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2. Literature review

According to Batageli, Janyani, and Tomai [12], optical communications are developing. It will be influenced by the sophistication and advancement that aids in overcoming the restrictions set. Coherent detection polarization multiplexing, digital processing, and multilayer modulations are required to fulfill the requirement for high quality, greater speed, and huge capacity.

According to Trichili et al. [56], the usage of spatial mode transmission of light is the essential remedy to address the anticipated capacity constraint. Spatial multiplexing modes have been proven via FSO lines, optical fibers, and underwater communication systems, in particular orbital angular momentum OAMs. As a result of the growth in information technology and the resulting necessity to migrate from the radio frequency to optical domain, Kaushal and Laddoum [57] demonstrated that the information industry was able to achieve greater data rates. The usage of free space optical FSO communication enables businesses to achieve their high-speed and demanding needs.

In order to promote multi-user communication through turbulence and suitable data processing, Kedar and Arnon [58] developed the adaptive field to mitigate the communication degradation by scattering.

Datacenter networks utilize the whole spectrum of fiber optic technology to offer coverage over the long haul in the sense of distance, as demonstrated by Lam et al. [59]. The properties of intra-datacenter interconnects are crucial for developing data centers. Next-generation intra-data center interconnects might be made possible via a variety of technologies. Improved fiber optic communication infrastructure, lightwave optical transmission, signal modulation to address losses, and other methods of boosting high-speed interconnects between data centers are some of the techniques used to implement next-generation intra-data center interconnects.

Among the technologies used to construct next-generation intra-data center interconnects are improved fiber optic communication infrastructure, lightwave optical transmission, signal modulation to overcome losses, and other ways to increase high-speed interconnects between data centers.

A probabilistic Lugiato-Lefever equation was proposed by Pfeifle et al. [61] as a way to predict the laser pump intensity jitter and amplified spontaneous emission noise brought on by an erbium-doped fiber amplification. Try out cutting-edge modulation techniques for optical fiber transmission. By using crystalline whispering-gallery-mode reflectors with a center frequency for a comb generation, they show that, when noise is taken into consideration, the prominent comb's coherence is significantly better than their solitonic or unstable counterparts with virtually the same pump power.

A general description of a ROF architecture is given by Thomas, Elhajjar, and Hanzo [62] before they go into depth regarding ROF techniques for enhancing system performance. Finally, they discussed the ROF methods developed to make installing a ROF device less expensive.

To simultaneously quantify nonlinear noise power and OSNR generated by fiber nonlinearity, Yang and He [63] suggested a technique based on an LSTM network. During the training phase, the LSTM network produces the crucial characteristics using a frequency-domain input signal.

For certain ultrashort optical pulses propagating in the nonlinear inhomogeneous fiber, Gao [64] carried out a symbolic calculation using a recently developed simplified higher-order variablecoefficient Hirota formula. The congregation envelope function connected to the optical-pulse electric domain of the fiber is constructed using an auto-Backlund transmutation and a variety of analytical solutions.

A unique C-RoFN architecture for MSRO leveraging software-specified networking was presented by Yang et al. [65]. The suggested architecture would effectively make use of radio frequency, BBU processing services, and the optical spectrum to increase radio coverage and adhere to QoS requirements.

The paradigm developed by Milione, Nolan, and Alfano [66] can be used to identify the theoretical modes of an MMF. Their suggested approach, the modebased signal delay system, expands the MMF of a comparable strategy for determining the main factors influencing single-mode optical fiber distortion. In order to establish an optical fiber communication system that comprised the whole chain of a transmitter, receiver, and channel model, Karanov et al. [67] employed an end-to-end deep neural network. Transceiver optimization is possible using this technique during single end-to-end transmission. They proved that bit error rates may be kept below the HD-FEC threshold of 6.7% by using this method with the intensity modulation/direct detection (IM/DD) system.

The benefits of digital fiber nonlinearity compensation, which divides digital signal processing between the receiver and the transmitter, were studied by Lavery et al. [68]. The Gaussian noise implementation demonstrates that dividing nonlinearity correction when there are two or more periods is frequently advantageous.

A fundamental nonlinear equalizer based on functional-link neural networks (FLNN) was developed and proven by Zhang et al. in [35]. They generally use signals from two polarizations and map features as data to produce an FLNN in order to overcome fiber nonlinearity in optical communication transmission systems. The FLNN may function as a nonlinear network thanks to the nonlinear probabilistic mapping.

3. Discussions and comparisons

Based on a thorough analysis of the works devoted to optical fiber communications, it can be said that the problems are being addressed. The most well-known difficulties are cost, QoS, performance, dispersion, performance, performance, speed, quality, communication degradation, employing the complete spectrum of fiber optics, and estimation of nonlinear noise power. The author Challenges Solutions Batageli, et al. [12] Speed, Quality coherent detection polarization multiplexing, digital processing, and multilevel modulations .Trichili et al. [56] foreseen capacity crunch spatial mode communication of light .Kaushal et al. [57] meeting the business requirements free-space optical FSO communication is used .Kedar et al. [58] reducing the communication degradation adaptive field Lam et al.[59] .Datacentre networks using the full spectrum range of fiber optic technologies photonic integrated circuits, improved fiber optic communication infrastructure, lightwave optical transmission, signal modulation to resolve losses

Temprana et al. [60] cancelling Kerr-induced transformations Fiber information capability can be substantially improved concerning previous estimates.

Pfeifle et al. [61] Proposing an estimate for laser pump intensity jitter and enhanced spontaneous emission noise caused by an erbiumdoped fiber amplification using a probabilistic Lugiato-Lefever equation. Experiment with advanced modulation formats in optical fiber transmission.

As a result, several solutions were offered to address all of these issues.Coherent detection polarization multiplexing, digital processing, and multilayer modulations were the focus of certain researchers' study. Others simultaneously worked on improving fiber optic communication infrastructure, developing photonic integrated circuits, lightwave optical transmission, and signal modulation to reduce losses. However, a different pattern emerged when the LTSM network was used to train the key features by exploiting the input signal's frequency domain.The researcher's primary focus was on developing and testing a training method that results in adaptable and reliable transceivers that permit secure transmission over a variety of connection dispersions without reconfiguration. Author Challenges Solutions: Thomas et al. [62] Performance and cost presenting the ROF architecture's standout features.Yang et al. [63] Estimating nonlinear noise power and OSNR induced via fiber nonlinearity. When training an LTSM network, the input signal's frequency domain is used to create the crucial characteristics.Gao et al. [64] Dispersion, speed An auto-Bäcklund transmutation and a family of analytic solutions are designed for the congregation envelope function related to the fibre's optical-pulse electric domain. Yang et al. [65] They are improving radio coverage and meeting the QoS constraints. It is efficiently leveraging radio frequency, BBU processing services, and the optical spectrum. Milione et al. [32] We are determining an MMF's theory modes. We are assessing the main factors that contribute to single-mode optical fiber distortion. Karanov et al. [67] demonstrating the first step towards end-to-end deep

learning-based optical fiber communication system optimization In simulations, proposing and testing a training technique that produces flexible and robust transceivers enables secure transmission over a wide range of connection dispersions without reconfiguration.

Lavery et al. [68] Examining the advantages of digital fiber nonlinearity compensation The use of the Gaussian noise model is used to show that it is typically desirable to separate the nonlinearity correction when there are two or more period

Zhang et al. [69] proposed and demonstrating a basic nonlinear equalizer based on functional-link of neural networks (FLNN). To combat fiber nonlinearity in optical communication transmission systems, one can build an FLNN primarily using signals from two polarizations and mapped features as input.

4. Conclusions

This article presents the primary research problems for optical communication technology. Indeed, there has been substantial progress in the area of optical communications due to the competition for faster speeds, more economy, and enormous capabilities. In summary, our study aimed to investigate the advancements in optical fiber communication and its implications. We examined various aspects such as signal transmission, bandwidth capacity, and signal quality. Through our research, we have found that optical fiber communication offers significant advantages over traditional copper-based systems.

Firstly, optical fibers enable the transmission of signals using light, which results in higher bandwidth capacity. This increased capacity allows for the efficient transmission of large amounts of data over long distances. Compared to copper cables, optical fibers have a much greater potential for supporting future data-intensive applications.

Furthermore, optical fiber communication exhibits superior signal quality. The use of light eliminates interference from electromagnetic radiation, resulting in clearer and more reliable data transmission. This makes optical fiber communication particularly suitable for applications requiring high-speed and high-quality data transfer, such as telecommunication networks and internet services.

However, despite its numerous advantages, there are still challenges that need to be addressed in the field of optical fiber communication. These include the cost of installation and maintenance, as well as the need for specialized equipment and expertise. Efforts should be made to make optical fiber communication more affordable and accessible, especially in rural and underdeveloped areas.

In conclusion, our research highlights the significant benefits of optical fiber communication, including its high bandwidth capacity, superior signal quality, and ongoing technological advancements. While there are challenges to overcome, the potential of optical fiber communication in revolutionizing modern connectivity and enabling the future of telecommunications is undeniable. Further research and development in this field are crucial to unlock its full potential and ensure its widespread adoption.

DECLERATIONS

CONFLICT OF INTERSET

The corresponding author declare that this manuscript is their own work, and no funding, grants, or any financial support related to this manuscript is received.

ETHICAL APPROVAL

The corresponding author declares that this manuscript is their own work, and has not been published before in any journal and/or conference, and it is never been considered for publication or submitted to any other journals**.**

CONTRBUTIONS

NJJ proposed the study of the manuscript, and NJJ gave a valuable revision and illustration of some concept. NJJ wrote the article and suitable editing, and reading, and approved the final version.

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AVAILABILITY OF DATA

Not applicable

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