

# OPTICAL FIBERS AND THEIR APPLICATION IN COMMUNICATIONS

Rafal Adnan Hasan

Nineveh Education Directorate/Umm Al-Rabi'een Secondary School for Distinguished  
Students

[rafalsyala@gmail.com](mailto:rafalsyala@gmail.com)

## Abstract

Fiber optic technology is a modern and innovative method used to transmit data across different geographical regions. It offers several advantages, including high speed, long transmission distances, and excellent signal quality.

Numerous studies and practical applications have proven that using fiber optics provides high quality and is the optimal choice both technically and economically. Fiber optics have many benefits, such as low signal loss and lightweight construction, but the most important feature is their extremely high bandwidth capacity, reaching thousands of billions of bits per second. This has made them a prominent solution in the field of telecommunications, replacing copper wires in a variety of applications, including long-distance lines, underwater cables, and telephone exchange connections.

The massive revolution in communications and information, especially the unlimited use of the internet, has created a new reality that cannot be achieved without networks capable of transmitting enormous amounts of data—something only fiber optics can deliver. However, despite their advantages, using this optical technology for long-distance data transmission faces some drawbacks, such as high cost and installation complexity.

Beyond telecommunications, fiber optic technology has wide applications in fields like medicine and scientific research. Due to their flexibility and precision, they are used in various digital cameras for medical imaging, such as endoscopy and radiography.

**Keywords:** fiber, communications, geography, scientific applications

## Introduction

### Concept of Fiber Optics

The technique of sending data via light pulses that pass through lengthy fibres, usually composed of glass or plastic, is known as fibre optics. Depending on the energy needs and transmission distance, these fibres are made to help light travel. Fibre optics are favoured for communication over metal lines because they are immune to electromagnetic interference and can transfer signals with less harm.<sup>(1)</sup> Traditional optical fiber can be defined as a fiber made of glass with a high degree of purity, known as dissolved quartz (silicon dioxide SiO<sub>2</sub>), or it is made of polymer, which is as thick as a human hair, and the group of fibers arranged in a tight shape is what is known as an optical cable. A fiber optic cable can contain a varying number of fiberglass fibers that may reach a few hundred. Optical fiber allows light to be transmitted over longer distances and at higher bandwidths (data rates) than electrical cables. Fiber optics have a core surrounded by a cladding layer made of an insulating material. Light signals are confined to the core by creating a refractive index greater than the covering.<sup>(3)</sup>

Light rays can be used to transmit a lot of data using optical fibres, which operate on the principle of total internal reflection. However, unless we have a long, straight wire with no bends at all, it will be difficult to take advantage of this feature. To prevent this, optical wires are made so that all light rays bend inwards and travel continuously, bouncing off the fibre

optic walls and transmitting data from (1) When light enters at a certain angle, The refractive index of the core must be higher than the refractive index of the cladding for reflections to occur within the fibre where they meet. An optical fibre segment shows light reflection within the fibre, which can be explained by Snell's law and radiation theory at a critical angle of incidence. The angle of the refracted ray is  $90^\circ$  with respect to the vertical line or parallel to the core-covering boundary, and when the angle of incidence surpasses the inflection limit threshold, the radiation is reflected inside the core, which is called the internal total reflection. Optical signals degrade when they cross gradual and long distances depending on the purity of the material used, but the use of metal cables leads to a greater loss compared to other wires used.<sup>(1)</sup>

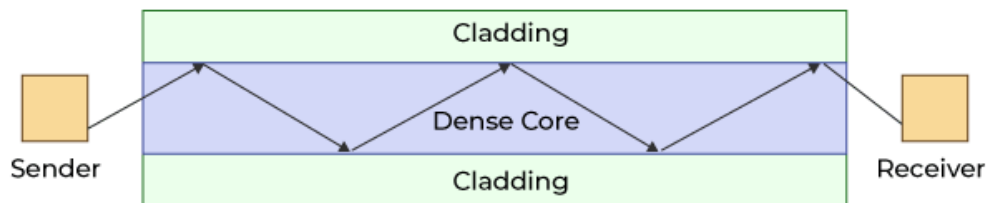


Figure 1: Method of light transmission within the optical fiber

The optical fiber is basically composed of three cylindrical layers superimposed on top of each other: <sup>(5)(6)</sup>

- 1. Heart:** It is a central cylinder and is considered the most important part of optical fibers, as it consists of thin and dense optical fibers made of pure glass, which transmits light signals where most of the light transmitting information is propagated, its diameter ranges between 62.5 and 9 micro depending on the type of fiber.
- 2. Inverter (sheath):** It is a second glass cylinder that surrounds the first and is centered with it, differing from it in terms of refractive index, as it has a refractive index lower than the refractive index of the heart material, thus providing the necessary condition for the propagation of light - or most of it - inside the heart through the phenomenon of internal total reflection.
- 3. Protective cover:** It is a plastic shell that surrounds the reflector, with a diameter of about (250) microns, this wrap is useful in protecting the fiber from damage, breakage, and moisture, and in giving it the necessary flexibility to handle it easily (as the glass material of the core and the reflector is very fragile and breakable).

The aforementioned parts represent the minimum in the fiber manufacturing loop, and are used in this form only in laboratories, and cannot be used in practical field applications directly, and for field use, other fiber reinforcement operations are performed. (Figure 2)



Figure 2: Reinforced optical fiber

The optical fiber is usually surrounded by an outer shell whose function is to protect the hundreds of fibers that result in the form of bundles. After the fibers are gathered together in the form of a cable, all the necessary protection measures are taken for it, such as not compressing the fiber, protecting it from loop operating conditions, which require resistance to climatic conditions, resistance to interruptions, protection from rodents, and resistance to severe bends. This allows you to get a fiber optic cable that contains a group of fibers, each of which can transmit the appropriate information. (Figure 3)

The diameters of fiber cables are about one millimeter for low-reinforced and low-fiber cables (which include two pairs of fibers), to a few centimeters for high-strength and high-fiber cables (which include dozens of fibers).

The length of a single piece of cable is 2 to 4km when used for communications. When a communication line of fiber optic cables is extended, the cable pieces are connected to give the appropriate length. In most cases, the connection is done with the opposite fiber weld in the two cables, and then the soldering point is strengthened so that there is no mechanical weakness in the cable or a position of light loss.

When used in sensor systems, the parts required are often short and depend a lot on the application.

Figure 4 shows a real image of fiber optic cables mounted on a trolley to extend them.<sup>(5)</sup>



### Fiber Optic Working Technology

These fibers rely on delivering light through long and straight lines, where the light reaches the fibers without any problem because it travels through straight lines, and in case of any curvature that hinders the movement of the fiber path, it will reduce the quality of the signal, and the problem of bending inside the path can be overcome through a mirror that transmits light. The light signal can travel over long distances because the wall does not absorb the light falling on it.<sup>(6)</sup>

Many types of amplifiers, a wire with several fibre optic beams that are routed through buildings and underground channels, an optical transmitter that transforms an electrical signal into an optical signal to be sent to an optical fibre, and an optical receiver that transforms the signal back into an electrical signal are all common components of optical communication systems. Digital information produced by computers, phone systems, and wired television companies typically makes up the transferred data..<sup>(7)</sup>

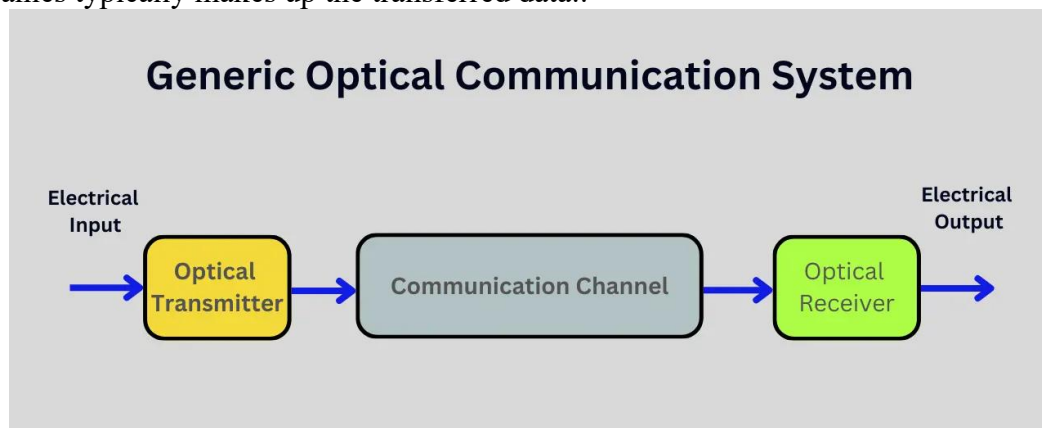


Figure 5 Fiber Optic Core Communication System Transmitters

It is the element that generates the optical signal injected into the fiber. The signal is not generated randomly, but in a way that expresses the information to be transmitted (whether speech, computer, or television) and the speed of its change, and then the information coding, modification, assembly, and other processes are applied. The transmitters used are supposed to meet some requirements, the most important of which are: <sup>(5)</sup>

- Sufficient power for the light signal to reach the end of the fiber so that it is detectable.
- A radiation model of the transmitter that must conform to the fiber in order to inject the efficiency effectively.
- Editability, with the aim of uploading information in an appropriate way.
- High speed. To transmit signals and information with rapid changes.
- Small size, weight and cheap price, to maintain a reasonable connection cost.

In modern (digital) communication systems, a series of electrical pulses corresponding to the information can be generated and then given to the transmitter who converts them into light pulses, meaning that each electrical pulse is matched by a light burst that is injected into the fiber and transmitted through it to the receiver.<sup>(5)</sup>

Semiconductor devices like light-emitting diodes and laser diodes are the most often used phototransmitters. The distinction between the two is that the former create distorted light,



whereas the latter produce undistorted light. Semiconductor optical transmitters must be built to be small, dependable, and efficient. They must also function in an ideal wavelength range and form directly at high frequencies in order to be used in optical communications. In its most basic configuration, the light-emitting diode is a forward-biased p-n curve that spontaneously emits light—a process known as electroluminescence.. A comparatively broad spectral width of 30–60 nm obscures the light that is released. The light-emitting diode's light transmission is also inefficient; only around 1% of the energy is converted into free energy and connected to the optical fibre. Nonetheless, photoemitting diode lamps are particularly helpful for low-cost applications, and their design is rather straightforward. Since the inGaAsP diversion works at a longer wavelength than the GaAs dielectric, these are frequently communication lamps made by the enzyme zinc oxide phosphate inGaAsP (or gallium arsenide, GaAs). whereas its wavelength is 1.7 times wider than its energy equivalent. Higher fibre dispersion affects photoemitting diode lights' wide spectrum breadth, significantly reducing the distance between bits. The lamps perform well in local area network applications with transmission range of a few kilometres and rates ranging from 10 to 100 Mbit/s. For local area networks, lamps that emit light at various wavelengths across a broad range have also been created and are currently in use. VSCSEL devices, which offer better speed, power, and spectrum properties at a comparable cost, power a substantial portion of photoemitting diodes.

In addition to other advantages associated with coherent light, semiconductor laser lamps have a higher power output of roughly 100 mW because they emit light by catalytic emissions rather than spontaneous emissions. Because the laser's light is comparatively directed, single-mode fibres can achieve a high double efficiency of roughly 50%. High bit rates are also possible due to the narrow spectral breadth, which lessens the impact of chromatic dispersion. Additionally, due to the fast reinstallation time, semiconductors can be directly manufactured at high frequencies. Lasers used in optical fibres are one type of semiconductor transmitter that is frequently employed. Since laser diodes are frequently installed directly, a current applied directly to the device controls the light output. A continuous wave laser source, the light produced by an external device, and an optical converter, like an electrodesorption modulator or an interferometer, can be used for very high data rates or very long distance communications. By removing laser impregnation, external shaping expands the link distance that can be accomplished. This enhances the fibres' colour dispersion by enlarging the directly embedded laser line. A transceiver is an apparatus that integrates two transmitters and receivers into a single residence.<sup>(7)</sup>

The external dimensions of the transmitter range from a few millimeters to a few centimeters, and they have different shapes, such as a rectangular, circular, or integrated circuit from one of the faces.

These transmitters offer optical speeds of up to a few milliwatts (1-3 mW) and the frequencies they can operate on are as high as a few hundred gigahertz (GHz).<sup>(5)</sup>

#### Fiber Optic

The function of the fiber is to transmit the signal between the transmitter and receiver sides. To ensure the reliability of the connection, the following must be present: <sup>(5)</sup>

- The fiber used must be within a cable that is adequately protected in investment conditions, such as severe bending, heat and humidity, durability from interruptions, protection from rodents, and others.



- Selecting the fiber so that its attenuation of the signal to be transmitted is not large, and allows for good detection of the signal at the receiver.
- The fiber provides the appropriate package width. Although the width of the fiber packet is wide, it is limited, and depends on the type of fiber used.

In the general case, for short distances (a few meters to tens of meters) affordable plastic fibers are used, and for medium distances (tens of meters to hundreds of meters) fibers Multi-style, in some cases can be used up to a few kilometers. For long distances, single-mode fibers are used.<sup>(5)</sup>

#### Receivers

Receivers are the main component of an optical receiver that is an image detector, which converts light into electricity using the electrical image effect.<sup>(7)</sup> The role of the receiver in detecting the light signal and converting it into an electronic signal can be summarized. Then the signal can be demodulated, coded, and distributed to the entrances of investors' lines.<sup>(5)</sup> The fundamental telecommunications images are found in arsenic, gallium, and indium, and the image detector is typically based on semiconductor light. A variety of photodiode types, such as n-p and p-i-n image diodes, as well as metal photodetectors (metal semiconductors), are also employed due to their suitability for circuit integration in wavelength division multiplexes and repeaters. In order to generate a digital signal in the field electrolyte from an incoming light signal that may be attenuated and distorted during its passage through the channel, electro-optical transformers are typically compared with opposing amplifiers and limit amplifiers. Before the fundamental data is delivered, other signals, including clock recovery from data carried out by a phase-locked loop, can also be handled.<sup>(7)</sup>

The photoreceptor consists mainly of two parts:<sup>(5)</sup>

- Optical detector: It is the element that receives the optical signal from the fiber and converts it into an electrical signal, and most of these elements are semiconductor optical detectors, and the most used are optical diodes.
- Processing electronics: Its function is to amplify, demodulate, and/or encode the electrical signal and make it usable.

The future must have two primary characteristics:<sup>(5)</sup>

- Good reception sensitivity, as the better the receiver sensitivity, the more reliable the transmission of information and the greater the range of transmission.
- Provide the appropriate frequency beam width, and then transmit the transmitted signal without any distortion.

The signal to be transmitted over optical fibers (sound, image, ...) is converted into electrical, then converted to optical by means of an optical transmitter, and transmitted through optical fibers.

Attempts are currently being made to cross from the signal to be transmitted to a direct optical signal, after combining it with other optical signals, and then transmitting directly to the optical fiber. The possibility of facilitating and simplifying transmission, modulation, encoding and loading of information on the fiber, known as all-optical communications, is being explored, and for this purpose a fiber optic amplifier is used, which amplifies the optical signal directly, and acts as a repeater for the signal, and the tables (collectors) of the optical signal and its splitters.<sup>(5)</sup>

#### Types of Fiber Optic Cables



A fiber optic cable consists of a core, a cover, and another cover that acts as an outer layer of protection. The inner cover directs light through the core by using the theory of full internal reflection. The core and cover are usually made of high-quality silica glass, but can be made of plastic. Two optical fibers are connected either by heat or mechanical conduction. The connection mechanism requires special skills and internal connection technology, because microscopic precision is required when describing cores. Fibers, there are two basic types of optical fibers used in optical communications, which are multiple optical fibers and single optical fibers. Fiber optics have a larger core, give lower resolution, and connect to cheap transmitters, as well as cheap connectors. Multi-fiber optics give a jamming that also reduces the length and width of the link, in addition to the fact that multi-fiber optics are expensive due to the high dopant content.

The core of the monofiber optic is smaller, requires expensive internal components and connection methods, but gives higher, longer performance links.

To put the fibers in the form of a commercial product, they are coated with a protective layer by using UV rays and fiber optic connectors, eventually becoming a usable cable. They can then be placed in the ground, inside the walls of buildings, or used in the air (the same as copper cables). These fibers do not require periodic maintenance as is the case with current wires.<sup>(7)</sup>

The basics that are relied on when designing a fiber optic cable can be summarized as follows:<sup>(8)</sup>

- Cable shape and appearance
- Durability strength or how hard the cable is.
- Tensile strength level.
- Cable flexibility.
- Temperature tolerance level.
- The size and thickness of the cable.
- The extent of its susceptibility to combustion or being affected by heat.

#### Types of Optical Fiber

Optical fibers are classified based on three basic factors, namely the refractive index, the materials used, and the method of light propagation, and the classification is as follows:<sup>(1)</sup>

Classification based on the materials used:

- Plastic optical fibers: It consists of a basic material for light transmission, which is polymethyl methacrylate.
- Glass fibers: They are made up of very fine glass fibers and are the best, most widely used, and widespread.

Refractive index classification:

- Step indicator fibers: It consists of a core surrounded by a clasp, which has a single uniform refractive index.
- Graduated indicator fiber: The refractive index of optical fibers decreases as the radial distance from the fiber axis increases.

Classification based on the method of light propagation:

- Single-mode: Single-mode optical fibres have a smaller core than multimode fibres and only permit the passage of one light. This type of fibre uses a laser as a light source, sending a single wavelength in a straight line below the fibre. Single-mode fibres have a higher



bandwidth and are the most appropriate fibre type for long-distance networks; they can carry long-distance signals with low loss, primarily used in communication systems..

- The multimode fibre optic cable has the advantage of allowing a large core to pass through, which increases the number of reflections as light passes. However, because the signal is typically scattered, the core size leaves a large field for light to bounce back as it sends the fibres down, degrading the signal quality. Additionally, the signal cannot be amplified, so it is only appropriate for short distances where simpler and less expensive transceivers can be used. There are two main types of multimode fibers:

- First: The most popular kind of multimode fibre in use today is multimodal fibre with a gradient index. Light moves more slowly along the axis than it does near the casing, which improves light ray collection. The refractive index progressively drops from the central axis towards the cladding. The farther light is from the central axis, the faster it will travel in an optical substance with a lower refractive index.

This type is popular in applications that require a wide range of wavelengths, particularly telecommunications, scanning, imaging and data processing systems.

- Second: Multimedia fibers with a step indicator: This type of fiber transmits light in zigzag paths and directly bounces off the cover, and the result is that different modes of light arrive at different times on the other end of the fiber.

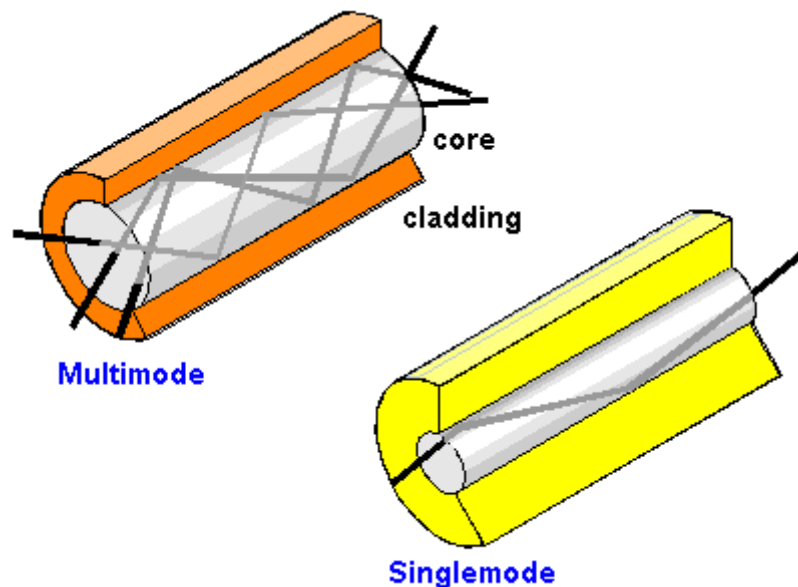


Figure 6: Mode of light transmission through optical fibers of different styles

What distinguishes single-mode fibers is that they allow for longer bonds and higher performance efficiency, while multimode fibers include a core of more than 50microns that helps low-resolution transceivers connect to them and is cheaper than other connectors. The problem here is that multimode fibers limit bandwidth as well as link length, are expensive, and sometimes the two types of fibers are combined to varying degrees They are then terminated with fiber optic connectors, and assembled to be packed to be commercially viable, and one cable can contain 1,000 optical fibers.<sup>(9)</sup>

Why is fiber optic the best choice for data transmission?



Fiber optic communications, when compared to other methods of data transmission, such as copper wires, have a large number of benefits, including: <sup>(10)</sup>

#### Speed

Optical fibers allow for faster data transfer speeds than previous technologies, while copper internet connections can transmit data at 50Mbps, optical fibers can be used for speeds above 1 Gbps and have been successfully tested at speeds 1000 times faster.

#### Distance

When it comes to transmission distance, optical fibers come out on top, as they can send data tens of miles with minimal signal loss, as these cables use light instead of electricity.

#### Physical aspects

Fibre optics is at the top of the telecommunications list in the modern world because, when compared to other media, fibre optic cables are much lighter, have a smaller diameter, and are more resistant to corrosion and rust because of their non-metallic construction.

#### What type of light is used in fiber optics?

Fiber optic technology uses several types of light such as: <sup>(11)</sup>

- Infrared light: within a wavelength of 0.9-0.8  $\mu\text{m}$ , or 1.6-1.3  $\mu\text{m}$ .
- Lasers: It is excellent in maintaining the stability of the signal and preventing it from being cut or weakened.

#### What is a Fiber Optic Network?

A fiber optic network is a network of cables that transmit information from one place to another, for example: <sup>(11)</sup>

- The fiber optic network that transmits information from the Internet to the home is called FTTH, which is short for Fiber to the Home, or in another term (Fiber to the premises, or FTTP).
- Network that transmits from source to distributor (Curb) It is called (Fiber to the curb, FTTC for short).
- The network that transmits from the source to the building is called (Fiber to the Building) (FTTB).

#### Fiber Optic Features

We have become in today's world where we do not dispense with the Internet, or fast communication and communication, so we have found fiber optic technology that helps in data transfer, and one of the most important features of optical fibers is the following<sup>(8)(14)(13)(12)</sup>

- Bandwidth and speed

Fiber optic cable can accommodate extremely high bandwidth and speed, and the huge amount of data that can be sent per unit of fiber optic cable is perhaps the most important feature, Because fibre optics are more expandable, it is simple to add new equipment to the original fibre, and wavelengths can be turned on or off, making it easier to provide services and growing a business. Additionally, fibre optics are lighter and much smaller than copper wires, and these fibres are typically laid in anticipation of expanding needs 15 to 20 years from now.

- Affordable

Most optical fibers nowadays are made of silica material, which is abundant in the sand, which is much less expensive than the copper metal that has begun to be implemented in many places in the world, and for this reason, Although long-distance fibre optic networks are more costly than copper networks, their long-term growth potential makes the initial investment worthwhile. Additionally, the cost of transmitting various types of information will be lower



than that of other systems. Because optical fibres are becoming more and more prevalent, competition has increased across the globe and among optical fiber companies and thus the prices of capital expenditures have decreased significantly as the number of fiber producers has continued to increase due to the increasing need for optical fibers.

- **Signal strength and connection quality**

In addition to having a low error rate, optical fibres are resistant to electromagnetic interference, which is a disturbance caused by electromagnetic radiation from an external source. Any object carrying electrical currents can cause interference, including industrial electromagnetic sources like motors, generators, and various electrical devices, as well as natural ones like the sun and lightning. Moreover, the signal loss in fibre optic cables is significantly lower than that of copper cable

- **Data Protection**

Security is a major concern for companies today, since light is the medium that transmits information in optical fibers, and this light does not generate any magnetic field outside the cable, it is very difficult to spy and know the information contained in the optical cable, and it is also difficult to know the existence of the optical cable because of the material made from it, and there is no metal component, with the exception of certain situations in which a steel cable is added to reinforce the optical cable or to protect it from external loads and rodents. As a result, it is extremely difficult to intercept transmitters when they are transmitting or sending information because there is no way to listen for them passing by and it is also easy to identify violations as they occur because any actual interruption in the system will lead to the failure of the overall system, these wires are not tamperable. Also, the conductive light cannot create a spark or a short circuit because there is no electric current in it, and for this reason, optical fibers can be used in shops containing gases or combustible materials and warehouses of hazardous materials, as they are not flammable, which reduces the risk of fires, and the possibility of electrification of workers in optical fibers is out of the question.

- **Lightweight and low thickness**

Since optical fibres are lighter than copper cables and have been developed to drastically reduce dimensions, they are a better fit for environments with limited space. As a result, optical cables can be added in the same paths as copper cables in a variety of wired communications fields, and as a result, copper cables have been replaced with optical fibres in many ships and aeroplanes. They are speedier than copper cables and easier to transport and install because of their tiny size and low weight.

- **Longevity**

Fiber optics are expected to have a lifespan of 25 years compared to fifteen years for other systems, as the primary components of fiber are stainless glass. The useful life of a fiber optic cable is usually around 100 years, making it a suitable return on investment.

- **Pulses of Light**

This type of interference does not occur when using optical fibers, no matter how close the distance between them, unlike electrical communications sent through copper cables, where more brittle phone calls or better TV coverage result from the optical signals from one fibre in the same fibre connection not interfering with those from the other fibre.

- **Doubles the versatility**

Fiber optic is more flexible and adaptable than copper wires of the same dimensions, fiber optic cable is highly configurable, bends easily, and withstands most of the acid components



that come into contact with copper wires, and because these optical fibers are so thin they don't actually break when wrapped around corners just a few centimeters in size. Glass can also be exposed to varying temperatures in terms of low and high, and can be used in environments containing chemicals without being damaged.

#### Applications of Fiber Optic in the Field of Communication

As telecommunication applications are widely distributed, ranging from desktop computers to global networks, the uses and applications of optical fibre have expanded greatly. These applications include the transmission of voice, data, or video over distances ranging from less than a metre to hundreds of kilometres as companies need secure and reliable systems to transfer data and financial information between buildings to desktop stations or computers, and they also need them to transmit data around the world, and optical fibers can be used In several fields, including: <sup>(10)(11)</sup>

- **Computer Networks and Broadcasting:** Because optical fibres can transmit data and offer high bandwidth, they are commonly used in computer networks. Similarly, optical fibres are widely used in electronics and broadcasting to improve performance and communications..
- **Internet and cable TV:** Two of the most popular applications for optical fibre are the internet and cable TV. Long-distance communications between computer networks located in various places can be supported by installing optical fibres..
- **Marine Environments:** Optical fibers are used in the most vulnerable environments, such as undersea cables, where they can be submerged in water and do not need to be replaced often, in addition to being free of electromagnetic interference, it does not negatively affect the flow of information transmission, and thus the stability and strength of the signal.
- **Military and Aerospace:** Because fibre optic cables are compact and light, they may be used for temperature sensing, and the military and aerospace sectors can benefit from optical fibre as a communication and data transmission tool.
- **Medical Field:** Optical fibers are frequently used in a variety of medical instruments, such as biomedical sensors that aid in minimally invasive medical procedures, and because they are not subject to electromagnetic interference, they are ideal for various tests such as MRI scans, and other medical applications of optical fibers include X-ray imaging, endoscopy, light therapy, and surgical microscopy.

In addition, there are many fields in different fields that have started to benefit from optical fibers, and it is very difficult to identify all the areas in which optical fibers can be used, as they are used in lighting places that are not visually accessible, such as sailboat pumps and engines, as well as in mechanical inspections in checking pipes to detect damages and malfunctions that are difficult to reach, and it is also widely used in decorations and Christmas trees, and in sonar and earthquake applications.

#### Disadvantages of Fiber Optic

Despite the enormous and amazing advantages of optical fibers, there are some disadvantages that should be considered, including: <sup>(8)(10)(13)(15)</sup>

- The cost of system components is very high, in addition to the high cost of its testing equipment, and the cost of installing and maintaining this technology is higher than some other technologies. Although the costs are lower in the long run, the costs of fiber installation are still significant to implement, and special testing equipment is often needed along with installers who have good knowledge about the placement of the fiber optic network, in addition



it may take specialized equipment to diagnose a problem with the fiber optic network, leading to costly repairs in case the cables are damaged.

- They are fragile, as optical fibers are sensitive to breakage and damage, which requires care during installation and maintenance, they are thinner, lighter and heavier than copper wires, and this makes the system more sensitive, and due to their small size and being made of glass or plastic, they can be easily cut by accident during building renovations and other construction work or wire refurbishment, and because fiber optic cables can transmit much more data than metal networks, fewer cables serve a larger number. This means that just one cable cut may disrupt service for a large number of businesses and individuals.
- It needs effort and labor when installing it, it needs to employ professional and competent specialists with high experience for the purposes of maintenance and installation, and for inspection and evaluation when joining optical fibers together, and special devices to verify the transmission of the fiber cable.
- Fiber optic cables are limited to transmitting light in one direction only, and if bidirectional communication is a necessary part of the transmission of information within the network, two simultaneous cables must be placed in order to achieve bidirectional propagation of information.
- Fiberglass optics need layers of protection to cover them within the cable itself.
- Severely restrict the energy of light-emitting sources, although high-energy emitters can be obtained to enhance power delivery, they come at an additional cost.
- Minimize the length of the distance between the transmitter and receiver, or repeaters are necessary to maximize signal strength.

Although there are some drawbacks to owning a fiber optic network, it is considered one of the best modern technologies that has saved time and money in various fields of industry and is better in terms of industrial security.

Finally, we can say that fiber optic cables offer many advantages that are much more efficient when compared to copper cables, as the amount of network bandwidth that a fiber optic cable can carry easily and easily outweighs a copper cable of equal or similar thickness.

Optical cables can also transmit data at lightning-fast speeds of up to 100 Gbps, as light can travel longer distances without weakening its power through fiber optic cables.

In the case where fiber optic coverage is used, the need for signal boosters becomes less than before, in addition to the fact that the fiber optic cable is less susceptible to electromagnetic interference, especially in the case of a network cable made of copper that needs shields to protect it from electromagnetic interference, although the fiber optic cable does not need this as the physical properties of fiber optic cables protect it from this problem.

The first appearance of optical fibers made of glass was in the early 1950s and its use was limited to theorizing, while in 1966 engineers (George Hockham and Charles Kao) used it in the field of communications and was made of silica.<sup>(9)</sup>

Finally, it can be said that this technology has made a great transition in the field of communication and communication by facilitating the process of transferring data and information, which has taken the place of copper cables, especially today in a world that requires communication and in a continuous and indispensable development of the Internet, which facilitates phone calls and downloading videos or photos from Internet sites and others, nowadays optical fibers are used everywhere in homes, industries, and offices for long distances, as well as for communication over small distances.<sup>(8)</sup>



## Sources

1. <https://mawdoo3.com> , "What is Fiber Optics?" Ghaida Al-Daraba, 3/7/2022.
2. "Optical Fibers and Their Applications in Communications", University of Al-Qadisiyah, Faculty of Education, Department of Physics, Heba Kazim, Hiam Mohsen, 2017.
3. "Optical Fiber", College of Basic Education/Haditha, University of Anbar, Eng. Ahmed Karim Samir, 20/9/2022.
4. "Optical Fiber and its Applications in Communications", University of Babylon / Faculty of Education for Pure Sciences - Department of Physics, Hadi Ibrahim, 2023.
5. <https://arab-ency.com.sy> , Encyclopedia of Science and Technology, "Optical Fibers", Shukri Al-Miqdad.
6. <https://www.fakera.com> , "A Search for Optical Fibers with Elements", Mawadda Sharif, 22/3/2024.
7. <https://ar.wikipedia.org>, "Fiber Optic Communication", 7/6/2024.
8. <https://www.almrsal.com>, "Advantages and Disadvantages of Optical Fibers", Esraa Harb, 21/10/2023.
9. <https://www.almrsal.com> , "A Comprehensive Search for Optical Fibers", Yasmine Saleh, 25/3/2022.
10. <https://mawdoo3.com>, "Uses of Optical Fibers in the Field of Telecommunications", Zeinab Malkawi, 20/11/2022.
11. <https://mawdoo3.com> , "Types of Optical Fibers and the Uses of Each Type", Hind Abu Dames, 28/11/2022.
12. "Industrial Electronics", pp. 145-149, Jihad Duraid, Othman Arfaia, Bassel Abdel Haq, Youssef Shukair, Ibrahim Mahmoud, 21/8/2023.
13. <https://www.almrsal.com>, "Pros and Cons of Optical Fibers", Alaa, 25/3/2022.
14. <https://ar.wikipedia.org> , "Optical Fiber", 2019.
15. <https://mawdoo3.com> , "Uses of Optical Fibers in the Military Field", Fidaa Al-Rashidat, 17/8/2023.