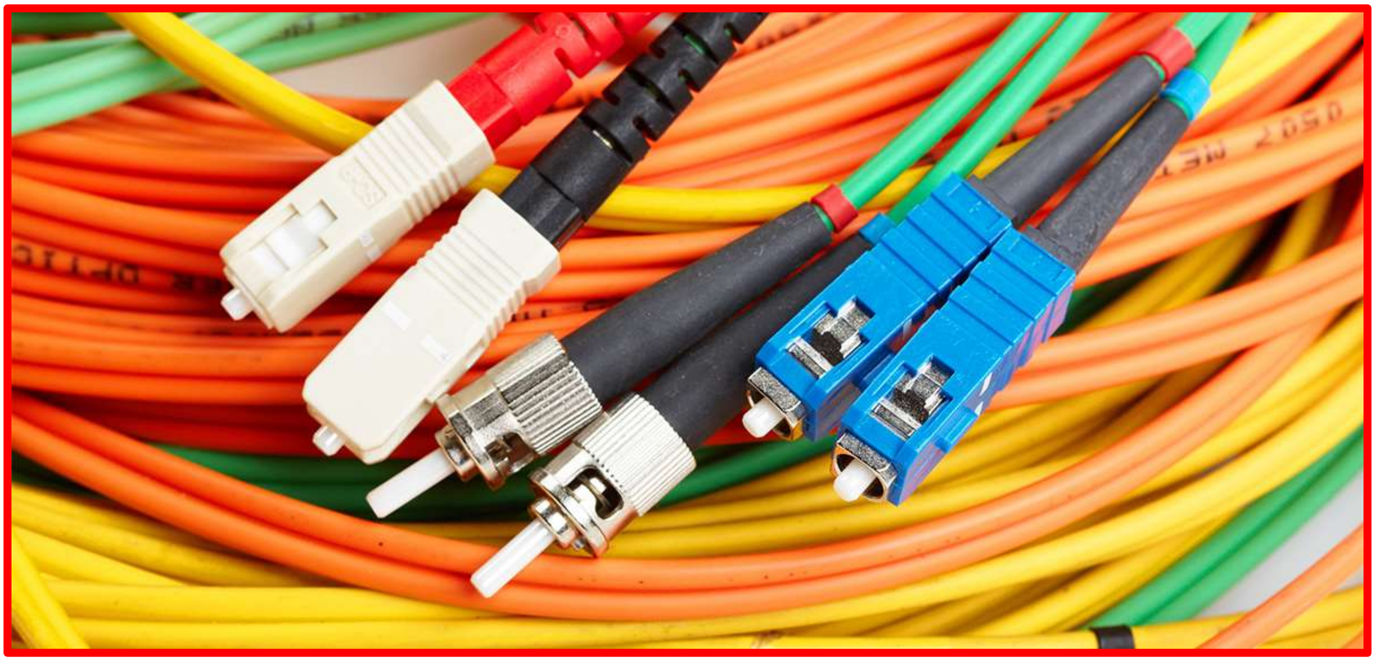
# Fiber Optics

Optical Fibers are flexible glass or plastic Fibers that can transmit light from one end to the other. These Fibers find widespread use in Fiber-optic communications, where they allow transmission over longer distances and at higher bandwidths (data transmission rates) than electrical cables.



# Module 1: Fiber Optics Material

Fiberglass: Both the core and cladding are glass. As a result, it has low loss, long transmission distance and high cost. Silicone rubber Fiber cladding: the core is glass, and the cladding is plastic. The properties are like those of optical Fiber, but the cost is lower.

Plastic Fiber: The optical Fiber core and cladding are made of plastic. Therefore, plastic Fiber has high loss, short transmission distance and low price. It is mostly used for home appliances, audio, and image transmission over short distances.

Multimode vs. Single mode: The central core of multimode Fibers is thicker (fifty or sixty-two and a half micrometers), which can transmit light from multiple modes. However, this also contributes to significant dispersion, which limits the transmission frequency of digital signals. Therefore, the transmission distance of multimode optical Fiber is short only a few kilometres. Single-mode Fibers contain very thin glass Fibers (nine or ten micrometres). Single-mode Fibers can transmit light only in one mode. Therefore, its inter-mode dispersion is very small, which is suitable for long-distance communication. The simplest way to distinguish them is that the outer sheath of single-mode Fibers is yellow, and the outer sheath of multimode Fibers is orange.

Optical Fibers are long strands of high-grade, purity glass that are as thin as a human hair. These strands are lined up together in a bundle called an optical cable. If you look closely at one of these optical Fibers, you will find that it is:

The core, which is a core of ultra-pure glass, represents the path through which light travels. Cladding, which is the outer material surrounding the glass core, is made of glass whose refractive index differs from the refractive index of the glass from which the core is made, and it continuously reflects light N In order to remain inside the glass heart Buffer Coating.

It is a plastic cover that protects the heart from damage. We find that hundreds, or even thousands, of these Optical Fibers are lined up together in one bundle to form the optical cord, which is protected by an outer cover called a jacket.
We find that Optical Fibers are divided into two basic types:

The first type: Single Mode Fiber, in this type, only one optical signal is transmitted in each optical Fiber of the bundle, and it is used in telephone networks and television cables. This type of optical Fiber is characterized by being small, as the radius of its glass core reaches about “9 microns” and rays pass through it the laser Infrared or wavelength 1.3-1.55 nm.

The second type: Multi-Mode Fibers: In this type, many optical signals are transmitted through a single optical Fiber, which makes its use better for computer networks. This type in nature has a larger radius, as it reaches “62.5 Microns” and infrared rays are transmitted through it.

# Module 2: How do Optical Fibers work?

How do Optical Fibers work? How is light transmitted through it?
You must assume, for example, that you want to deliver a flash of light along a long, straight path. In this case, all you must do is direct the light through this path, because light travels in straight lines and because it reaches the other side without any problem. But what if this path has bends? In this case, you can easily overcome it by placing a mirror at the bend to reflect the light back into the path. In the same way, the problem is solved if the path is very curved, so that a row of mirrors is made along the path to... We reflect light continuously on the wall adjacent to the glass heart, "cladding" in the form of a total internal reflection. Because this wall does not absorb any light falling on it, the light signal can travel further and longer distances, but sometimes it happens that part of the light is lost and the reason for this is that the impurities in the glass core absorb it.

**What does a Fiber Optic system consist of?**
We find that the Fiber Optic system consists of three parts, which will be discussed in detail:

The first part, "Transmitter":
It is the part that produces and encodes the optical signal, so that the basic part of it is the light source, which may be a laser or an optical diode. For example, if we want to transmit a television signal or any information, it is necessary to modulate that optical signal according to the information we want to convey. By modifying this light signal, we find that its intensity may be changed by changing it up or down (analogue modulation), or turning it on or off in succession, which in this case is what is known as "digital modulation."

The second part, "Fiber Optic":
It is through which the optical signal is delivered over long distances, and it is the part that was previously explained above in detail. You can return to it and read it again.

The third part, "receiver":
It receives an optical signal, decodes it to convert it into an electrical signal to send it to the user, which is: the television or the telephone.

**Advantages of optical Fiber:**
We find that Optical Fibers have caused a major revolution in the world of communications, due to their distinction from ordinary connecting wires, and this is due to several features, including:

It has a high ability to carry and transmit information because Optical Fibers are much thinner than ordinary wires, and it is of course possible to place many of them inside one bundle, and this helps to increase the number of telephone lines or the number of television broadcast channels in one rope. It is sufficient for us to know that the bandwidth of Optical Fibers reaches fifty "THZ", while we find that the largest bandwidth needed by television broadcasting does not exceed six tenths of "6 MHz". Optical Fibers are characterized by their smaller size, as their diameter is less than half the diameter of the well-known and traditional copper wires. For example, it is possible to replace a copper wire with a diameter of seven point sixty-two centimeters with another Fiber-optic wire, but its diameter does not exceed six hundred Thirty-five thousandths 0.635 cm This, of course, is of great importance, especially when laying wires underground. Optical Fibers are also lighter in weight. It is possible for copper wires that weigh, for example, ninety-four and a half kilograms to be replaced with Optical Fibers that weigh only three point six, 3.6 kilograms.

Another advantage of it is that its signal loss is very small and almost non-existent, and the small percentage of loss is caused only by the impurities that are present in it. It is also impossible to interfere with the signals that are transmitted through neighboring Fibers in the same single cable. This, of course, ensures the clarity of the transmitted signal, whether it is a telephone conversation, a television broadcast, etc. One of its advantages is that it is not exposed to electromagnetic interference, which makes the signal transmitted completely confidentially Of course It is of very great importance for military purposes in particular.
One of its wonderful features is that it is not flammable, which helps reduce the risk of fires. We also find that it is characterized by lower energy consumption and therefore requires a smaller number of generators. This is due to the loss during the connection process being very small.

# Module 3: How to make optical Fibers?

How are Optical Fibers made?
As we previously mentioned, Optical Fibers made of glass that has an extremely high degree of purity, as one company described it as such. She said: If there is an ocean of Optical Fibers that extends for many miles, and you look from its surface at the top to the bottom, you will see the bottom clearly and easily. Optical Fibers are manufactured as follows:

- Manufacture and manufacture of an unshaped glass cylinder.
- Optical Fibers are pulled from this glass cylinder.
- Optical Fibers are tested.

The glass that is used to make this unshaped cylinder is made through a process called Modified Chemical Vapor Deposition, where oxygen is passed over a solution of silicon chloride, germanium chloride, and other chemicals as well, and then the rising vapors are passed into a tube Quartz is placed in a special lathe It does this work, and when it is rotated, a high-temperature thermal device called a brazier moves around the quartz, where the high temperature causes two very important things to happen:
Silicon and germanium react with oxygen to form silicon oxide and germanium oxide. After that, silicon oxide and germanium oxide are poured onto the wall of the tube from the inside and they merge to form the required raw glass, where it is then possible to control the degree of purity and purity of the glass formed by controlling the thread.
After all of this, the Fibers are pulled from this raw and not yet shaped cylinder, and placed in the drawing device, where the raw glass is lowered into a carbon furnace with a temperature of one thousand nine hundred to two thousand and two hundred degrees Celsius, and its front begins to melt until the melt descends Some of them are influenced by gravity and simply Its fall then creates the light strand. This strand is processed through sequential wrapping while being pulled by a tractor or puller with a continuous measurement of the radius using a laser micrometre, and the Fibers are pulled from the raw mold at a rate of ten to twenty 10-20 M/s.

After that, the Fibers are tested in terms of their refractive index, geometric shape, especially the radius, their endurance, their resistance to tension, the scattering of optical signals through them, their capacity to carry information, their tolerance to temperatures, and the ability to deliver images while underwater.

Although the use of Optical Fibers to transmit information over large and long distances has received most of the attention, it is also used to transmit information over short distances as it connects the main computer to side computers or a printer. Aside from the field of communications, there have been many other important uses for these Fibers. For example, because of its flexibility and accuracy, it has been used in the manufacture of digital cameras for multiple uses in medical imaging, such as endoscopic and folk photography. It also entered the manufacture of cameras used in mechanical photography to inspect welding and connections in pipes and generators and to examine long sewer pipes from the inside.

Optical Fibers were also used as sensors to determine the change in different temperatures and pressures. Because of their quality, they were preferred over ordinary sensors, of course, due to their small size, small sensitivity, and accuracy of performance. We find that one of their important applications is in using them These are sensors for measuring Strain pressure by inserting them in the manufacture of the wall of some aircraft, which gives the plane a distinctive wall that warns the pilot of the atmospheric pressure on the wings or the outer fuselage. In the end, we find that Optical Fibers are considered a wonderful technological revolution in various fields, including communications, networks, electronics industries, and aircraft.

# Module 4: Use optical Fibers?

What are the advantages of using optical Fiber?
In our daily life, communication transmission media include cables, optical Fibers, and radio waves. As an important transmission method for wired communication, optical Fiber transmission has unique advantages compared with wireless transmission and other wired communications.

Low cost and easy to install compared to a traditional cable (copper wire in general), the cost of manufacturing Optical Fibers is lower, because the main component of Optical Fibers is silica Fibers, and it is clear that the cost of glass is much lower than the cost of a copper cable. In general, the size and weight of optical cable is better than the size and weight of cable, so it is easier to construct.

High transmission rate, long transmission distance since the optical Fiber transmission signal has three windows with typical wavelengths of 850 nanometers, 1310 nanometers, and 1550 nanometers, it can be A single pair of optical Fiber can easily reach a transmission rate of 10 10 Gbps. This is beyond the reach of other means of transmitting signals. At the same time, the attenuation of the optical Fiber signal is very low, generally less than 3 decibels in a 10-kilometer optical Fiber, and about 10 decibels in a 100-meter cable. Therefore, Optical Fibers are particularly suitable for high-capacity, long-range communications, and transmission applications.

High safety, strong stability compared with electrical signals and radio signals, traffic lights have high security and are difficult to intercept or eavesdrop. At the same time, compared with the wireless signal, the wired signal is more reliable, will not be affected by natural weather and radio interference, and the signal is stable and reliable; However, the cable's transmission signal is still affected by electromagnetic radiation, which may cause signal distortion or even interruption, but the optical cable's transmission signal is not restricted. In fact, because the optical Fiber itself is not conductive, it can avoid safety accidents caused by lightning and electrical leakage to a certain extent.

Environmental protection and pollution-free
The main material of optical Fiber is glass fibre. Its production process determines that it is more environmentally friendly than cables, and its transmission characteristics determine that it does not produce electromagnetic radiation and radio interference, so it can be considered pollution-free.

Overview
Because of the above advantages of optical Fiber, the optical cable has replaced the cable in most scenarios, and our most personal experience is that the optical Fiber broadband has entered the home, and the copper cable used to enter the home has been gone forever.
However, as we move towards the 5G era, will optical Fiber transmission face new challenges? In fact, as 5G provides more and more services, the demand for data bandwidth is also increasing, and the business support pressure of optical transmission system is also increasing.
At present, the transmission capacity of the backbone transmission network has quietly increased to the T level (1024 g). The development of mobile Internet in the future is still inseparable from the strong support of optical Fiber transmission.

# The difference between Optical Fibers and Fiber Optic cables

What is the difference between optical Fiber and Fiber Optic cable?

First: The topological structure of the optical Fiber access network. The simplest topological structure of a communication network is linear, star, and ring. The combination of these three basic structures makes a double star. Ring/star, double ring, tree, net, etc. Among them, line, star (including multi-star), tree and mesh networks are suitable topological structures for optical Fiber access networks.

1. The linear network structure has flexible upstream and downstream services, and can save optical Fiber and simplify equipment, so it has a wide range of application possibilities.

2. The star network structure can be expanded and updated according to the needs of both capacity and business service content; The multiplexing coefficient of the feeding part of the multi-star structure is very large, so using the star structure can greatly save optical Fiber. Quantity and construction cost are two of the most important network topology factors in the development of optical Fiber input networks.

3. The tree-shaped network structure is suitable for transmitting radio information, but its application has some limitations. But it has great application prospects in cable TV or telecommunication light source optical network (PON) using TDMA or CDMA technology.

4. The mesh network structure is economical, flexible, low maintenance and operation cost, convenient network upgrade, and has great advantages in network access.

Second, the configuration of the optical Fiber user access system at present, the user's peripheral equipment belongs to the electrical equipment access network (such as computers, telephones, fax machines, telephones, etc.), so between the central office and the user, light waves are used as when What wave is used? Carrier and optical Fiber As a transmission medium, conversion between the optical signal and the electrical signal must be performed at both ends. The main components of the optical communication system are the light source, optical Fibers, and photodetector. Under the influence of the electrical signal, the light source at the original end sends out the corresponding optical signal to complete the electrical/optical conversion task. Commonly used light sources are semiconductor laser diodes and semiconductor light-emitting diodes. When the receiving end receives the optical transmission sent by the transmitting end via optical Fiber, the optical detector first converts the received optical signal into a corresponding electrical signal, and then through amplification and equalization, it is restored to the desired electrical signal. It can be noted that the photodetector is the main device for receiving the optical signal. In optical Fiber communications, commonly used photodetectors are PIN photodiodes and avalanche photodiodes. Optical Fibers play the role of a medium in transmitting signals. Optical Fibers can be divided into single-mode Fibers and multi-mode Fibers according to their transmission modes. When only one mode can be transmitted in a fibre, it is called single-mode fibre, and when multiple modes are transmitted at the same time, it is called multimode fibre. Currently, there are three carrier wavelengths used in Fiber Optic communications systems: 0.85 pm, 1.31 pm, and 1.55 pm. This first-generation Fiber Optic communication system uses 0.85pm wavelength and multimode Fiber. 2nd and 3rd generation optical Fiber communication systems use the 1.31pm wavelength, multimode Fibers, and single-mode Fibers. The latest 4G optical Fiber communication system uses 1.55pm wavelength, single-mode Fiber. The working frequency of optical Fiber is wide, and the frequency of the transmitted signal is high, which can meet the needs of full-service transmission.

Optical cable refers to the final optical cable with an outer jacket, and optical Fiber refers to the Fiber core used for transmission in the optical cable, but some people also call the optical Fiber of the optical cable.