What is an Optical Fibre?

Optical fibre is the technology associated with data transmission using light pulses travelling along with a long fibre which is usually made of plastic or glass.

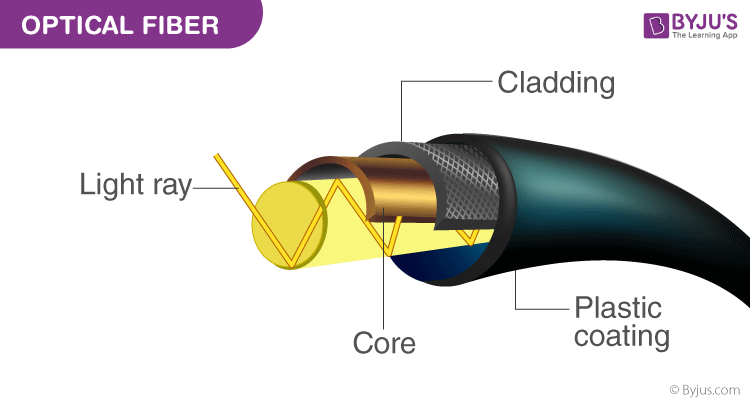
Metal wires are preferred for transmission in optical fibre communication as signals travel with fewer damages. Optical fibres are also unaffected by electromagnetic interference.

The fibre optical cable uses the application of total internal reflection of light. The fibres are designed such that they facilitate the propagation of light along with the optical fibre depending on the requirement of power and distance of transmission.

Single-mode fibre is used for long-distance transmission,

while multimode fibre is used for shorter distances.

The outer cladding of these fibres needs better protection than metal wires.



Types of Optical Fibres

The types of optical fibres depend on the [refractive index](https://byjus.com/physics/refractive-index/), materials used, and mode of propagation of light.

The classification based on the refractive index is as follows:

* **Step Index Fibres:**It consists of a core surrounded by the cladding, which has a single uniform index of refraction.
* **Graded Index Fibres:**The refractive index of the optical fibre decreases as the radial distance from the fibre axis increases.

The classification based on the materials used is as follows:

* **Plastic Optical Fibres:**The polymethylmethacrylate is used as a core material for the transmission of light.
* **Glass Fibres:**It consists of extremely fine glass fibres.

The classification based on the mode of propagation of light is as follows:

* **Single-Mode Fibres:**These fibres are used for long-distance transmission of signals.
* **Multimode Fibres:**These fibres are used for short-distance transmission of signals.

The mode of propagation and refractive index of the core is used to form four combination types of optic fibres as follows:

* Step index-single mode fibres
* Graded index-Single mode fibres
* Step index-Multimode fibres
* Graded index-Multimode fibres

How Does an Optical Fibre Work?

The optical fibre works on the principle of total internal reflection. Light rays can be used to transmit a huge amount of data, but there is a problem here – the light rays travel in straight lines. So unless we have a long straight wire without any bends at all, harnessing this advantage will be very tedious. Instead, the optical cables are designed such that they bend all the light rays inwards (using TIR). Light rays travel continuously, bouncing off the optical fibre walls and transmitting end to end data. Although light signals degrade over progressing distances, depending on the purity of the material used, the loss is much less than using metal cables. A Fibre Optic Relay System consists of the following components:

* The Transmitter – It produces the light signals and encodes them to fit to transmit.
* The Optical Fibre – The medium for transmitting the light pulse (signal).
* The Optical Receiver – It receives the transmitted light pulse (signal) and decodes them to be fit to use.
* The Optical Regenerator – Necessary for long-distance data transmission.

Advantages of Optical Fibre Communication

* Economical and cost-effective
* Thin and non-flammable
* Less power consumption
* Less signal degradation
* Flexible and lightweight

What is used for the fabrication of optical fibres that are used for communication?

Silica or multi-component glass are used for the fabrication of optical fibres.

Why is silica used for the fabrication of the optical fibres?

Silica has a perfect elasticity until it reaches the breaking point, which makes it best for fabrication.

What is the principle of fibre optical communication?

Total internal reflection is the principle on which the optical fibre communication is based.

Name the factors that are responsible for generating attenuation of optical power in fibre.

Following are the factors that are responsible for generating attenuation of optical power in fibre:

* Absorption
* Scattering
* Waveguide effect

Why are plastic-clad silica fibre optic cables not user-friendly?

Following are the reasons why plastic-clad silica fibre optic cables not user-friendly:

* The fibres are insoluble in organic solvents
* Bonding becomes difficult
* Connector application becomes difficult as there is excessive plasticity in the cladding

What is the Raman effect?

The Raman effect is the change in the wavelength of light which occurs when the molecules deflect the light beam.

What are the benefits of optical fibre cable?

Following are the benefits of optical fibre cable:

* The data security is excellent
* It is cost-effective
* It won’t be affected by interference

What is the bandwidth of optical fibre?

900 THz is the bandwidth of the optical fibre.

What is core in the optical fibre?

The core is the inner part of the optical fibre, which carries light.

List a few advantages of optical fibre communication.

A few advantages of optical fibre communication are:

* Less signal degradation
* Thin and non-flammable
* Economical and cost-effective
* Less power consumption

Basic Features of Optical Fiber

**Basic Features of Optical Fiber :** This article will cover the basic features of optical fiber used exclusively in Telecom's [SDH](https://www.technopediasite.com/2020/07/basic-features-of-optical-fiber.html) and [DWDM networks](https://www.technopediasite.com/2020/07/basic-features-of-optical-fiber.html). We all know very well that optical fiber used in communication systems consists of a cylindrical glass core and a glass cladding. The outermost layer is a plastic wear-resisting coating. The whole fiber is cylindrical.  
  
We also know that thickness of the core and refractive indexes of the core material and cladding material are critical to the properties of the fiber. We have been studying till now that optical fibers divide into two parts - single mode optical fiber and multimode [optical fiber](https://www.technopediasite.com/2020/07/basic-features-of-optical-fiber.html) but single mode [optical fiber](https://www.technopediasite.com/2020/07/basic-features-of-optical-fiber.html) has the advantages of low internal attenuation, large bandwidth, easy upgrades and capacity expansion and low cost. Now, I am going to explain below some important points about the basic features of optical fiber.

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| Features of Optical Fiber |

[Basic Features of Optical Fiber](http://www.technopediasite.com/)

Physical Dimension (Mode Field Diameter)

The single mode fiber core diameter is 8 ~ 9 μm in the same magnitude as the operating wavelength 1.3 ~ 1.6 μm. Due to the optical diffraction effect, it is not easy to measure the exact value of the fiber cord diameter.

Furthermore, since the field intensity distribution of the fundamental mode LP01 is not limited within the [fiber](https://www.technopediasite.com/2020/07/basic-features-of-optical-fiber.html) core, the concept of single mode fiber core diameter is physically meaningless and actually it should be replaced with the concept of mode field diameter. Mode field diameter measures the level of attention of the fundamental mode field spatial intensity distribution within the fiber.

The nominal mode diameter of the G.652 fiber in the 1310nm wavelength region should be 8.6 ~ 9.5μm with a deviation of less than 10%, and the nominal mode of the G.655 fiber in the 1550nm wavelength region should be filed 8 ~ 11 μm with deviations less than 10%.

Mode Field Concentricity Error

Mode field concentricity error refers to the distance between the mode field center and the cladding of the interconnected fiber. The fiber connector loss is proportional to the square of the mode field concentricity error.  
  
So reducing the mode field concentricity error is one of the major factors to reduce the loss of [fiber](https://www.technopediasite.com/2020/07/basic-features-of-optical-fiber.html) area and it should be strictly controlled in the process. Mode field concentricity error of two types of single mode optical fiber G.652 and G.655 should not exceed than 1. Generally, it should be less than 0.5.

Bend Loss

Diversion of optical fibers will cause radiation loss. Indeed, the bend arises for an optical fiber in two cases. One is that the curvature radius of the bend is much larger than the diameter of the fiber (such a bend can occur when fiber cable is laid). The second case is microbend. There are many reasons for microbends. Microbends not widely found it is limited to process conditions, can occur during the process of producing fiber and cable. Microbends of different curvature radii are randomly distributed along the fiber.  
  
The larger curvature radius bent fiber transmit fewer modes than the straight fiber, some part of modes also radiated out from the fiber to cause loss. Randomly distributed fiber microbands will result in mode coupling in the fiber and cause energy radiation losses. The twist loss of the fiber is unavoidable because it cannot be guaranteed that there will be no turning of the fiber and cable in any form during the production or use process.  
  
The twist loss or bend loss mode is related to the field diameter. The twist loss or bend loss of the [G.652 fiber](https://www.technopediasite.com/2020/07/basic-features-of-optical-fiber.html) should not be larger than 1dB at the 1550nm wavelength region, and the twist loss or bend loss of the G.655 fiber should not be larger than 0.5dB at the 1550nm region.

Attenuation Constant

The attenuation in [optical fiber](https://www.technopediasite.com/2020/07/basic-features-of-optical-fiber.html) is mainly determined by three types of losses: absorption loss, scattering loss and twist loss or bend loss. Bend loss, as described above, has no major effect on the attenuation constants in the fiber. So, it is the absorption loss and scattering loss that mainly determine the attenuation constants in the fiber.The loss of absorption is due to the fiber content where excessive metal impurities and OH-ions absorb light causing damage.Often scattering losses occur in the case that a portion of optical power is scattered outside the fiber core when uneven refractive index distribution emerges within the local field fiber and light scattering due to subtle changes in fiber material density and uneven density of compositions. Causes As SiO2, GeO2 and P2O5. Or, if some defect occurs or some bubbles and gas scabs persist at the core – cladding boundary, scattering losses may occur.  
  
The physical amplitude of these structural defects is much larger than that of lightwave, due to which the wavelengths scatter independently and shift the entire curve of the upward fiber loss spectrum. However, such scattering loss found in optical fiber is much lower than the former.  
  
If we combine the above losses, the attenuation constant of single mode fiber at 1310nm and 1550nm wavelength areas is 0.3~0.4dB/km (1310nm) and 0.17~0.25dB/km (1550nm), respectively. As per ITU-T Recommendation G.652, the attenuation constant at 1310nm and 1550nm should be less than 0.5dB/km and 0.4dB/km, respectively.

Dispersion Coefficient

Dispersion in optical fibers refers to a physical phenomenon of signal distortion, when different modes carrying signal energy or differing in different frequencies of a signal have different group velocities and dispersions from each other during propagation. Typically, three types of dispersion exist in optical fibers.  
  
**Modal dispersion:** This type of dispersion occurs when the fiber carries multiple modes of signal at the same frequency signal energy and different modes have different time delays during transmission.  
  
**Material dispersion:** Because the refractive index of a fiber core material is a function of frequency, the signal components of different frequency propagate along the fiber at different velocities. This causes dispersion.  
  
**Waveguide dispersion:** In the optical fiber, a signal travel different at frequencies in the same mode, This type of dispersion occur because of different group velocities during propagation.  
  
These three types of [dispersion](https://www.technopediasite.com/2020/07/basic-features-of-optical-fiber.html) are called chromatic dispersion. It is defines by the ITU-T G.652, a zero dispersion wavelength range of 1300nm~1324nm and a maximum dispersion slope of 0.093ps/(nm2.km). It is considered that at the wavelength range of 1525~1575nm, the dispersion coefficient is approximately 20ps/(nm.km). ITU-T G.653 defines a zero dispersion wavelength 1550nm and a dispersion slope of 0.085ps/(nm2.km) in the wavelength range of 1525~1575nm where the maximum dispersion coefficient is 3.5ps/(nm.km). The absolute value of the dispersion coefficient of G.655 fiber should be within 0.1~6.0 ps/(nm2.km) in the range of 1530~1565nm.

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| Dispersion characteristics of several types of fiber. |
| Dispersion characteristics of several types of fiber. |

[Dispersion characteristics](http://www.technopediasite.com/)

Cutoff Wavelength

To avoid modal noise and dispersion penalty, the cutoff wavelength of the shortest optical fiber cable in the system must be less than the shortest operating wavelength of the system. The position of the cutoff wavelength can at least guarantee single mode [transmission](https://www.technopediasite.com/2020/07/basic-features-of-optical-fiber.html) in the cable and suppress the occurrence of higher order modes or reduce the penalty of the generated high order mode noise power to a negligible degree. There are three types of cutoff wavelengths defined by ITU-T.  
  
➤It is considered the cutoff wavelength of primary coating fiber in jumper cable shorter than 2m.  
➤It is considered the cutoff wavelength of 22m cable optical fiber.  
➤It is considered the cutoff wavelength of 2~20m jumper cable.  
  
For G.652 fiber, the cutoff wavelength is 1260nm in 22m cable, 1260nm in 2~20m jumper cable, and 1250nm in jumper cable shorter than 2m. For G.655 fiber, the cutoff wavelength is 1480nm in 22m cable, 1470nm in primary coating fiber of jumper cable shorter than 2m, and 1480nm in 2~20m jumper cable.