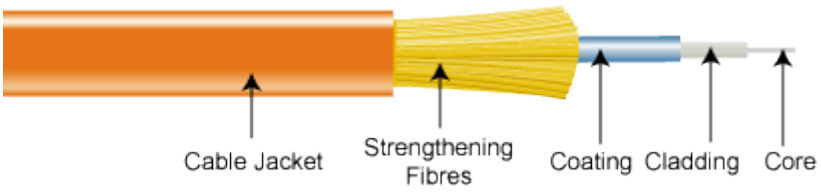
Fibre optic cable construction



Core

This is the physical medium that transports optical data signals from an attached light source to a receiving device. The core is a single continuous strand of glass or plastic that's measured in microns (µ) by the size of its outer diameter. The larger the core, the more light the cable can carry.

All fibre optic cable is sized according to its core's outer diameter. The three multimode sizes most commonly available are 50, 62.5, and 100 microns. Single-mode cores are generally less than 9 microns.

कोर

यह भौतिक माध्यम है जो संलग्न डेटा स्रोत से ऑप्टिकल डेटा संकेतों को एक प्राप्त डिवाइस तक पहुंचाता है। कोर ग्लास या प्लास्टिक का एक सतत निरंतर किनारा है जिसे इसके बाहरी व्यास के आकार के द्वारा माइक्रोन (a) में मापा जाता है। कोर जितना बड़ा होगा, केबल उतनी ही ज्यादा रोशनी लेगा।

सभी फाइबर ऑप्टिक केबल इसके कोर के बाहरी व्यास के अनुसार आकार के होते हैं। सबसे अधिक उपलब्ध तीन मल्टीमोड आकार 50, 62.5 और 100 माइक्रोन हैं। सिंगल-मोड कोर आमतौर पर 9 माइक्रोन से कम होते हैं।

Cladding

This is the thin layer that surrounds the fibre core and serves as a boundary that contains the light waves and causes the refraction, enabling data to travel throughout the length of the fibre segment.

आवरण

यह एक पतली परत है जो फाइबर कोर को घेरती है और एक सीमा के रूप में कार्य करती है जिसमें प्रकाश तरंगें होती हैं और अपवर्तन का कारण बनता है, जिससे डेटा फाइबर क्षेत्र की लंबाई में यात्रा करने में सक्षम होता है।

Coating

This is a layer of plastic that surrounds the core and cladding to reinforce and protect the fibre core. Coatings are measured in microns and can range from 250 to 900 microns.

परत

यह प्लास्टिक की एक परत है जो फाइबर कोर को सुदृढ़ और संरक्षित करने के लिए कोर को घेरे रहती है। कोटिंग्स को माइक्रोन में मापा जाता है और 250 से 900 माइक्रोन तक हो सकता है।

Strengthening fibres

These components help protect the core against crushing forces and excessive tension during installation. The materials can range from Kevlar® to wire strands to gel-filled sleeves.

Cable jacket

This is the outer layer of any cable. Most fibre optic cables have an orange jacket, although some types can have black or yellow jackets.

केबल जैकेट

यह किसी भी केबल की बाहरी परत है। अधिकांश फाइबर ऑप्टिक केबल में एक नारंगी जैकेट होता है, हालांकि कुछ प्रकारों में काले या पीले रंग के जैकेट हो सकते हैं।

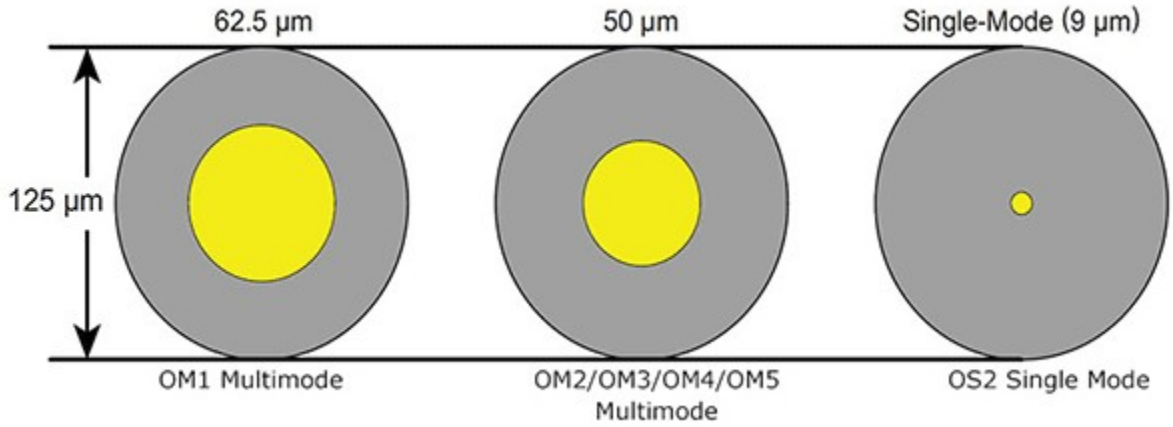
What's the Difference Between Multimode and Single-Mode Fibre Optic Cable?

Multimode Fibre Cable

Multimode cable has a large-diameter core that lets multiple modes of light pass through it. This means that more types of data can be transmitted.

Multimode comes in two core sizes and five varieties: 62.5-micron OM1, 50-

micron OM2, 50-micron OM3, 50-micron OM4 and 50-micron OM5. (OM stands for "optical mode".) All have the same cladding diameter of 125 microns, but 50-micron fibre cable has a smaller core (the light-carrying portion of the fibre).



Although all can be used in the same way, 50-micron cable, particularly OM5 and laser-optimised OM3 and OM4, provide longer link lengths and/or higher speeds, and are recommended for premise applications (backbone, horizontal and intra-building links) and should be considered for new installations. OM3, OM4 and OM5 can also be used with LEDs and laser light sources.
Multimode cables come in different colours so they can be easily recognised. OM3 is typically aqua; OM4 is sometimes Erika Violet (also known as Heather Violet in United Kingdom) to help distinguish it from OM3; the latest generation of multimode fibre, OM5, is lime green.

Multimode cable is made of of glass fibers, with a common diameters in the 50-to-100 micron range for the light carry component (the most common size is 62.5). POF is a newer plastic-based cable which promises performance similar to glass cable on very short runs, but at a lower cost.

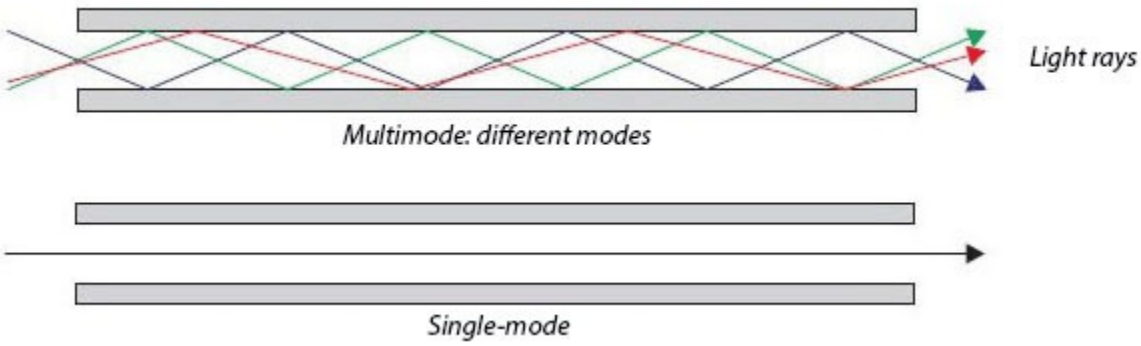
Multimode fiber gives you high bandwidth at high speeds over medium distances. Light waves are dispersed into numerous paths, or modes, as they travel through the cable's core typically 850 or 1300nm. Typical multimode fiber core diameters are 50, 62.5, and 100 micrometers. However, in long cable runs (greater than 3000 feet [914.4 ml), multiple paths of light can cause signal distortion at the receiving end, resulting in an unclear and incomplete data transmission

मल्टीमोड केबल ग्लास फाइबर से बना होता है, जिसमें लाइट कैरी कंपोनेंट के लिए 50 से 100 माइक्रोन रेंज में एक आम व्यास होता है (सबसे आम आकार 62.5 है)। POF एक नया प्लास्टिक-आधारित केबल है जो बहुत कम रनों पर ग्लास केबल के समान प्रदर्शन का वादा

करता है, लेकिन कम लागत पर।
मल्टीमोड फाइबर आपको मध्यम दूरी पर उच्च गति पर उच्च बैंडविड्थ देता है। लाइट वेव्स को कई रास्तों, या मोड में फैलाया जाता है, क्योंकि वे केबल के कोर के माध्यम से 850 या 1300nm से गुजरते हैं। विशिष्ट मल्टीमोड फाइबर कोर व्यास 50, 62.5, और 100 माइक्रोमीटर हैं। हालांकि, लंबी केबल रन (3000 फीट से अधिक [914.4 मिली)) में, प्रकाश के कई मार्ग संकेत प्राप्त होने पर विकृति का कारण बन सकते हैं, जिसके परिणामस्वरूप अस्पष्ट और अपूर्ण डेटा संचरण होता है।

Single-Mode Fibre Cable

In contrast to multimode, single-mode fibre cable has only one mode of propagation: a single wavelength of light in the fibre core. This means there's no interference or overlap between the different wavelengths of light to garble your data over long distances like there is with multimode cable.



Single-mode cable (OS2) has a small (8–10-micron) glass core that is much smaller than multimode and only one pathway of light or mode of propagation. (OS stands for optical single-mode.) With only a single wavelength of light passing through its core, single-mode fibre realigns the light toward the core center instead of simply bouncing it off the edge of the core as multimode does. OS1 is applied to inside-plant tight-buffered cable, whereas OS2 is applied to loose-tube cables.

Single-mode cable is almost always yellow, so it is easy to identify. Single Mode cable is a single stand of glass fiber with a diameter of 8.3 to 10 microns that has one mode of transmission. Single Mode Fiber with a relatively narrow diameter, through which only one mode will propagate typically 1310nm or 1550nm. Carries higher bandwidth than multimode fiber, but requires a light source with a narrow spectral width. Synonyms mono-mode optical fiber, single-mode fiber, single-

mode optical waveguide, uni-mode fiber.Single-mode fiber gives you a higher transmission rate and up to 50 times more distance than multimode, but it also costs more. Single-mode fiber has a much smaller core than multimode. The small core and single light-wave virtually eliminate any distortion that could result from overlapping light pulses, providing the least signal attenuation and the highest transmission speeds of any fiber cable type.Single-mode optical fiber is an optical fiber in which only the lowest order bound mode can propagate at the wavelength of interest typically 1300 to 1320nm.

सिंगल मोड केबल 8.3 से 10 माइक्रोन के व्यास के साथ ग्लास फाइबर का एकल स्टैंड है जिसमें ट्रांसमिशन का एक मोड है। एक अपेक्षाकृत संकीर्ण व्यास वाला एकल मोड फाइबर, जिसके माध्यम से केवल एक मोड आमतौर पर 1310nm या 1550nm का प्रचार करेगा। मल्टीमोड फाइबर की तुलना में उच्च बैंडविड्थ ले जाता है, लेकिन संकीर्ण वर्णक्रमीय चौड़ाई के साथ एक प्रकाश स्रोत की आवश्यकता होती है। समानार्थी मोनो-मोड ऑप्टिकल फाइबर, सिंगल-मोड फाइबर, सिंगल-मोड ऑप्टिकल वेवगाइड, यूनी-मोड फाइबर।सिंगल-मोड फाइबर आपको मल्टीमोड की तुलना में उच्च संचरण दर और 50 गुना अधिक दूरी तक देता है, लेकिन इसमें लागत भी अधिक होती है। सिंगल-मोड फाइबर में मल्टीमोड की तुलना में बहुत छोटा कोर होता है। छोटे कोर और एकल प्रकाश-तरंग वस्तुतः किसी भी विकृति को समाप्त करते हैं जो प्रकाश दालों को ओवरलैप करने के परिणामस्वरूप हो सकता है, कम से कम सिग्नल क्षीणन और किसी भी फाइबर केबल प्रकार के उच्चतम संचरण गति प्रदान करता है।

Multimode vs. Single-Mode Fibre Distance

Multimode fibre has a much shorter maximum distance than single-mode fibre, making it a good choice for premise applications. Single-mode fibre can go as far as 40 km or more without hurting the signal, making it ideal for long-haul applications.

Multimode vs. Single-Mode Fibre Bandwidth

Single-mode fibre has a significantly higher bandwidth than multimode fibre. You can use a pair of single-mode fibre strands full-duplex for up to twice the throughput of multimode fibre cable. Single-mode cable’s lengths and speeds are attainable because sending light in a single-mode nullifies differential mode delay (DMD) which is the primary bandwidth limiting factor of multimode.

Multimode vs. Single-Mode Fibre Pricing

Multimode and single-mode cables cost about the same. But multimode fibre systems are much cheaper than single-mode fibre systems and considered more cost-effective in the right application. This is due to the lower price of multimode transceivers and components. Multimode transceivers are generally two to three times cheaper than single-mode transceivers. Also, LED components used as transmitter optics in multimode devices are cheaper to purchase and calibrate.

step index and graded indexfibers

In step index fiber, the refractive index of core is uniform throughout and undergoes an abrupt change (step change) at the core cladding interface.

स्टेप इंडेक्स फाइबर में, कोर का अपवर्तक सूचकांक पूरे में एक समान होता है और कोर क्लैडिंग इंटरफेस में अचानक परिवर्तन (स्टेप चेंज) से गुजरता है।

Depending upon number of modes propagated by the fiber we have single mode and multimode step index fibers

I. Single mode step index fiber.

- A single mode or monomode step index fiber allows the propagation of only one traverse electromagnetic mode and hence the core diameter must be of the order of 2 μm to 10μm.
- It has high information carrying capacity.
- The single mode step index fiber has the distinct advantage of low intermodal dispersion, as only one mode is transmitted.
- It can be used for long distance communication
- It requires highly directional source such as LASER diode because of small

core diameter, hence the cost is higher than multimode step index fiber.

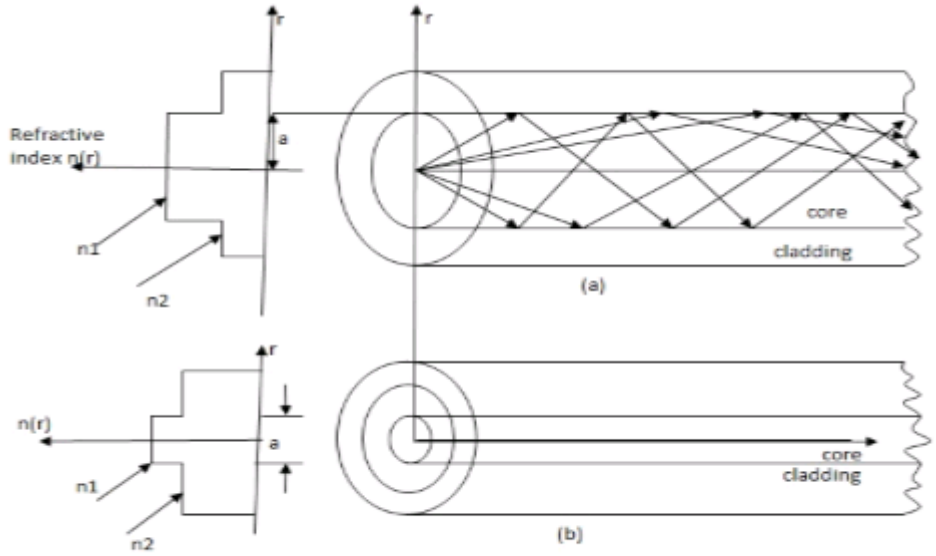


Figure 1.6: The Refractive Index profile and ray transmission in step Index fibers: (a) Multimode step index fiber; (b) Single-mode step index fiber

II. Multimode step index fiber.

- Multimode step index fiber with a core diameter of around 50 µm or greater allows the propagation of a finite number of guided modes along the channel.
- The total number of guided modes Ms for a step index fiber is given by

Ms=VSQURE/2

Where, V denotes the V-number which is a normalized frequency parameter.

- In multimode step index fiber dispersion is high due to the differing group velocities of the propagating modes.
- Due to high dispersion the information carrying capacity is less.
- It cannot be used for long distance communication as dispersion is a function of length.
- Simple to fabricate than single mode fiber and LED can be used as light source.

S. NO	STEP INDEX FIBER	GRADED INDEX FIBER
1.	The refractive index of the core is uniform throughout and undergoes on abrupt change at the core cladding boundary	The refractive index of the core is made to vary gradually such that it is maximum at the center of the core.
2.	The diameter of the core is about 50-200μm in the case of multimode fiber and 10μm in the case of single mode fiber	The diameter of the core is about 50μm in the case of multimode fiber
3.	The path of light propagation is ***zig- zag*** in manner	The path of light is ***helical*** in manner
3.	***Attenuation is more*** for multimode step index fiber but for single mode it is very less. *Explanation:* When a ray travels through the longer distances there will be some difference in reflected angles. Hence high angle rays arrive later than low angle rays causing dispersion resulting in distorted output.	***Attenuation is less.*** *Explanation:* Here the light rays travel with different velocity inn different paths because of their variation in their refractive indices. At the outer edge it travels faster than near the center. But almost all the rays reach the exit at the same time due to helical path. Thus, there is no dispersion.

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Numerical Aperture (NA): NA is the light gathering ability or capacity of an optical fiber. More the NA. the more efficient will be fiber. It is also known as figure of merit.

NA is related to refractive index of core (n1), cladding (n2) and outside medium (n0) as

$NA = \sqrt{n1^2 – n2^2}/n0$

If the medium is air then n0 =1, then

$NA = \sqrt{n1^2 – n2^2}$

Acceptance angle (θ): It is the maximum angle made by the light ray with the fiber axis, so that light can propagate through the fiber after total internal reflection.

Relation NA and acceptance angle:

NA = Sin θ

Acceptance cone: It is the cone in which the light incident at acceptance angle or less than the acceptance angle and then the light can propagate through the fiber after total internal reflection.

Fractional Refractive index change (Δ)= Δ = n1 – n2/n1

Relation NA and Δ:

NA = n1√2 Δ

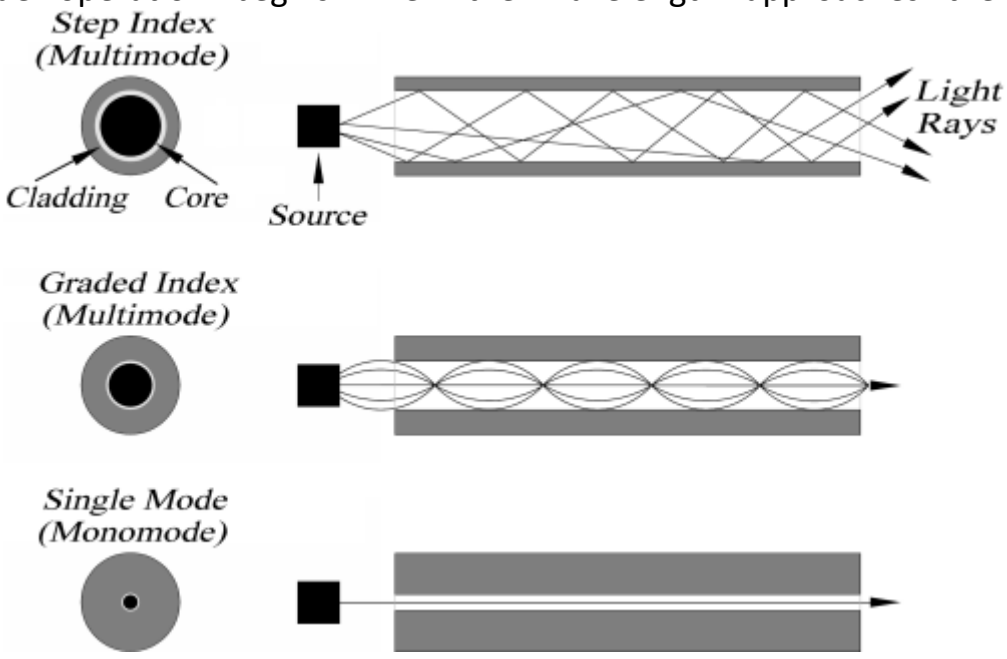
TYPES OF OPTICAL FI BER CABLE

There are three common types of fiber optic cables , as listed below. The suitability of each type for a particular application depends on the fiber optic cable's characteristics.

The single mode fiber optic cable, sometimes called a single-mode fiber cable, The single and multimode step-index fiber cables are the simpplest types of fiber optic cables. Single-mode fiber cables have extremely small core diameters, ranging from 5 to 9.5 um. The core is surrounded by a standard cladding diameter of 125 um. The jacket is applied on the cladding to provide mechanical protection. Jackets are made of one type of polymer in different colours for colour-coding purposes.

Single-mode fibers have the potential to carry signals for long distances with low loss, and are mainly used in communication systems. The number of modes that propagate in a single-mode fiber depends on the wavelength of light carried. A wavelength of 980nm results in multimode operation. As the wavelength is increased, the fiber carries fewer and fewer modes until only one mode remains.

Single-mode operation begins when the wavelength approaches the core diameter.



The multimode types of fiber optic cables, sometimes called a multimode fiber cable. Multimode fiber cables have bigger diameters that their single-mode counerparts, with core diameters ranging from 100 to 970 um. They are available as glass fibers (a glass core and glass cladding), plastic-clas silica (a glass core and plastic cladding), and plastic fibers (a plastic core and cladding). They are also the widest ranging, although not the most efficient in long distances, and they experience higher losses than the single-mode fiber cables. Multimode fiber cables have the potential to carry signals for moderate and long distance with low loss (when optical amplifiers are used to boost the signals to the required power). Plastic fiber optic cable is available in Fiberstore, it is an optical fiber made out of plastic rather than traditional glass. It offers additional durability for uses in data communications, as well as decoration, illumination and industrial application. FiberStore provides both simplex and duplex plastic optical fibers.

Multimode graded-index fiber are sometimes called graded-index fiber cables (GRIN). Graded-index and multimode fiber cables have similar diameters. Common graded-index fibers have core diameters of 50,62.5, or 85 um, with a cladding diameter of 125 um. The core consist of numerous concentric layers of glass, somewhat like the annular rings of a tree or a piece of onion. Each successive layer expanding outward from the central axis of the core until the inner diameter of the cladding has a lower index of refrection. Light travels faster in an optical material that has a lower index of refraction. Thus, the further the light is from the centre axis, the greater its speed. These types of fiber optic cable are popular in applications that require a wide range of wavelenths, in particular

telecommunication, scanning, imaging, and data processing stystems. In particular telecommunication, Multimode OM4 fiber optic cable is used in any data center looking for high speeds of 10G or even 40G or 100G. OM4 multimode fiber are ideal for using in many applications such as Local Area Networks (LAN) backbones, Storage Area Networks (SAN), Data Centers and Central Offices.