Single Mode and Multimode Fiber

Single Mode (SM) and Multimode (MM) are the names given to two competing designs of optical fiber based on how many paths of light are transmitted along the fiber core – single mode, meaning “one path”, or multimode, meaning “more than one path.” A mode can be described as a “path” or “ray” of light in the core of the optical fiber.

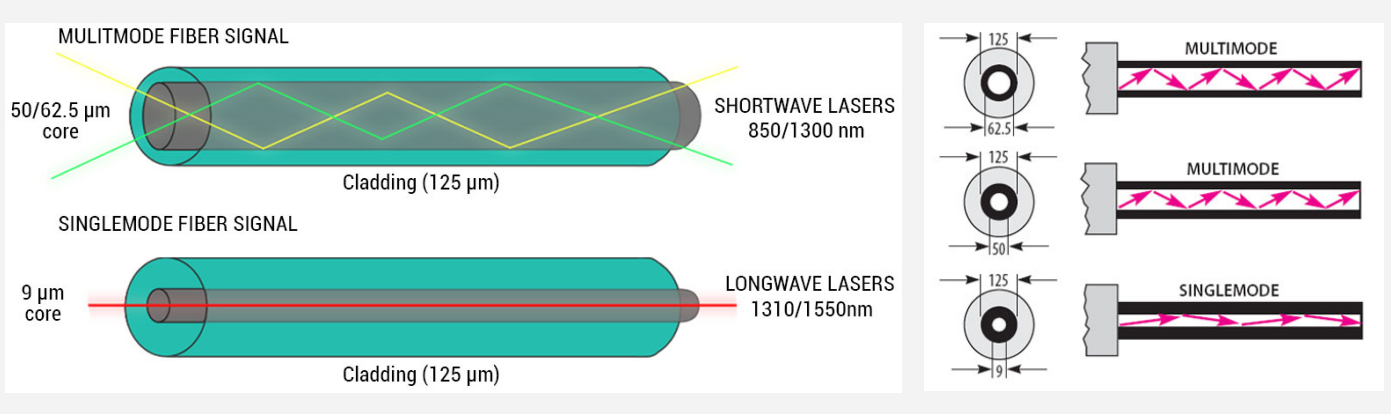
Optical fiber with just one path in the core was previously referred to as “monomode” (abbreviated as MM) but, due to confusion with the abbreviation also being used for multimode, the term “single mode” and abbreviation SM were adopted.

The size of the core diameter and the wavelength of light used for SM transmission are intricately linked to one another. The most common SM fiber core diameter, approximately 8 to 9 microns, is designed to transmit a single mode for wavelengths from 1260nm and longer i.e. for 1310nm and 1550nm. A shorter wavelength such as 850nm, used for MM transmission, will have more than one mode in a 9/125 micron SM optical fiber.

In a MM optical fiber, there are thousands of different paths that the light can follow depending on the diameter of the core and the transmission wavelength.

The way in which these two fiber types transmit light eventually led to their separate names. Generally designed for systems of moderate to long distance (e.g., metro, access and long-haul networks), single-mode optical fibers have a small core size (< 10 µm) that permits only one mode or ray of light to be transmitted. This tiny core requires precision alignment to inject light from the transceiver into the core, significantly driving up transceiver costs.

In comparison, multimode optical fibers have larger cores that guide many modes simultaneously. The larger core makes it much easier to capture light from a transceiver, allowing source costs to be controlled. Similarly, multimode connectors cost less than single-mode connectors as a result of the more stringent alignment requirements of single-mode optical fiber. Single-mode connections require greater care and skill to terminate, which is why components are often pre-terminated at the factory. On the other hand, multimode connections can be easily performed in the field, offering installation flexibility, cost savings and peace of mind.



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Similarities

The overall diameter of the cladding (outer layer of the glass) is the same for telecommunication MM and SM optical fiber, this is seen in other ways to describe optical fiber such as 8/125, 9/125, 50/125, 62.5/125 microns. The first number is the core diameter and the second number is the cladding diameter. The 125 cladding diameter was agreed on in an International Electrotechnical Commission (IEC) standards meeting compromising between the higher and lower diameters made by competing companies.

The materials used for SM and MM optical fiber are the same: silicon dioxide (SiO_2) for the glass structure of core, cladding, and additionally very small amounts of germanium (Ge) in the core to achieve a higher refractive index.

The protective coating materials used are common to both: two or three thin, flexible layers of polymer adhering to the 125 surface up to 250 micron. The outer layer contains pigment to help with identification.

Optical fibers must be packaged in protective cables to be used practically. These cables provide different types of protection depending on the installation method, the location in which the cables are being installed and the expected environment.

Differences

The most significant difference between SM and MM optical fiber is the size of the core and the impact this has on the transmission of signals and the active transmission/receiving (TX/RX) equipment that can be used.

SM fiber requires SM light sources which are edge-emitting LASERs (Light Amplification by Stimulated Emission of Radiation) for wavelengths from 1260nm to 1625nm. MM optical fiber operates at 850nm using lower cost VCSEL (Vertical Cavity Surface Emitting Lasers) MM light sources.

The key ingredient that makes optical fiber more than just a glass rod is germanium. This is a rare element that is used in other industries and is therefore in high demand. The quantity of germanium in MM fiber is significantly higher than in SM fiber which has an impact on the relative cost of the optical fiber types.

SM fiber can be used for any length of route from a few meters to hundreds of km as it has the benefit of optical amplification along the route for long distances, whereas MM fiber is used for routes from a few meters to 2 km.

The balance between the cost of active equipment and the cost of the optical fiber used is part of network owners' and designers' decision making process for short distance networks.

Fiber Type	Core Diameter	1 Gb Ethernet	10 Gb Ethernet	40 Gb Ethernet	100 Gb Ethernet
OM1 Multimode	62.5/125	275 Meters	33 Meters	Not Supported	Not Supported
OM2 Multimode	50/125	550 Meters	82 Meters	Not Supported	Not Supported
OM3 Multimode	50/125	550 Meters	300 Meters	100 Meters	100 Meters
OM4 Multimode	50/125	550 Meters	400 Meters	150 Meters	150 Meters
OM5 Multimode	50/125	550 Meters	400 Meters	150 Meters	150 Meters
Singlemode	9/125	Up to 2 Km using PSM4 transceiver			