Singlemode vs Multimode Optical Fibre

White paper

Introduction

Fibre optics, or optical fibre, refers to the medium and the technology associated with the transmission of information as light pulses along a glass or plastic strand or fibre. A fibre optic cable can contain a varying number of these glass fibres - from a few up to a couple hundred. Surrounding the glass fibre core is another glass layer called cladding. A layer known as a buffer tube protects the cladding, and a jacket layer acts as the final protective layer for the individual strand.

Just in the recent decades or two, it has become apparent that fibre-optics is steadily replacing copper wire as a better way for communication signal transmission. The fibre optics can span longer distances between local phone systems as well as providing the backbone for many kinds of network systems like data centres, university campuses, office buildings, industrial plants, and electric utility companies, and more. Fibre optics connects the world, carrying calls and data. There are two types of optical fibres commonly used for interconnecting different network devices: singlemode and multimode.

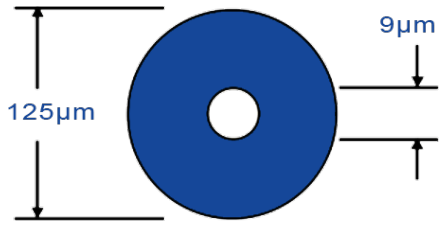
Nowadays more and more fibre-based networks have been built in the backbone and risers environment. Both multimode and singlemode fibres are available for the applications. But different fibre types have briefly different limitations for speed and maximum distance. These characteristics they possess and the way they cause the fibre to operate, determine the application to which a given fibre is most appropriate. Today's article will offer you some information about the classification of optical fibres and their differences in speed and distances.

This white paper introduces the definition and application of singlemode and multimode optical fibres and compare their differences.

Singlemode Optical Fibre

Generally called SMF, it is used for long distance communication. Singlemode fibre cable is a single stand of glass fibre with a diameter of 8.3 to 10 microns that features a common size of 9μm and has one mode of transmission.

Singlemode fibre 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 fibre cable type.



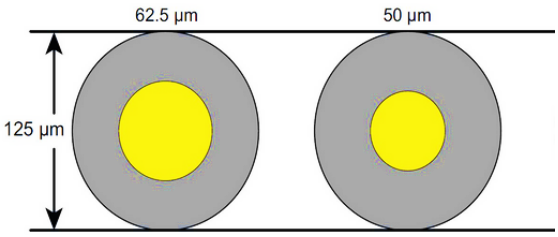
Singlemode fibre generally comes with a relatively narrow diameter, through which only one mode will propagate typically in 1310 or 1550nm band wavelength and carries higher bandwidth than multimode fibre that we will talk about later, but singlemode fibre requires a light source with a narrow spectral width. The synonyms of singlemode fibre are mono-mode optical fibre, singlemode fibre, singlemode optical waveguide and uni-mode fibre.

Singlemode fibre is used in many applications where data is sent at multi-frequency (WDM Wave-Division-Multiplexing) so only one cable is needed: singlemode on one single fibre.

Singlemode optical fibre is an optical fibre in which only the lowest order bound mode can propagate at the wavelength of interest typically 1300 to 1320nm.

Multimode Optical Fibre

Generally called MMF, it is used for short distances less than 500 meters. Multimode fibres, according to the specification and briefly by their bandwidth performance are commonly classified into OM1, OM2, OM3 and OM4. Each multimode type has different transmission data rates, link length and bandwidth for specific protocols, applications and transceiver types.



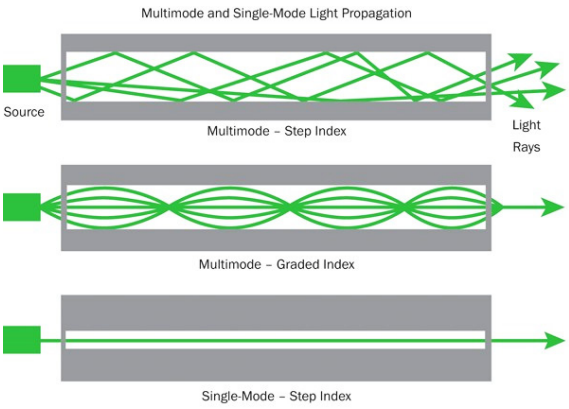
Typical multimode fibre core diameters are 62.5µm (OM1) and 50µm (OM2/OM3/OM4). However, in long cable runs, for example, long distance greater than 3000 feet or 914.4 meters, multiple paths of light can cause signal distortion at the receiving end, resulting in an unclear and in complete data transmission so designers now call for singlemode fibre in new applications using Gigabit and beyond.

Multimode fibre has a little bit bigger diameter than singlemode fibre cable, with a common diameter in the 50 to 100-micron range for the light carry component. Multimode fibre gives high bandwidth at high speeds (10 to 100MBS - Gigabit to 275m to 2km) over medium distances. Light waves are dispersed into numerous paths, or modes, as they travel through the cable's core typically 850nm or 1310nm.

What's the Difference Between them?

As mentioned above, the inner structure of singlemode and multimode fibres are diverse, this naturally leads to the following differences:

A. Light Propagation Difference



- The light propagation between singlemode fibre and multimode fibre is totally different
- Multimode fibre has two types of light propagation - step index and graded index, while singlemode fibre has only one step index. And the light propagation reduces less in the singlemode fibres transmission than that of multimode fibres

B. Optics Difference

- The light propagation between singlemode fibre and multimode fibre is totally different
- Singlemode fibre needs to be used with laser diode based fibre optic transmission equipment for precise calibration required to inject light into the cable. While Multimode fibre is usually used with LED based fibre optic equipment for short distance transmissions. In addition, singlemode connectors used for singlemode fibre also have higher stringent alignment requirements than that of multimode fibre connectors.in the singlemode fibres transmission than that of multimode fibres

C. Deployment Cost Difference

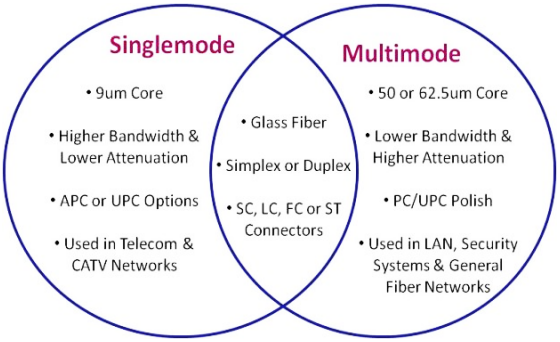
- Singlemode fibre cable systems are usually more expensive even though the actual cost of singlemode fibre cable is cheaper than that of multimode fibre cable in the market
- This is because it is the optics that dominates the total cost of a network system. For example, singlemode transceivers cost 1.5 to 4 – 5 times more than multimode transceivers, depending on data rate
- Furthermore, multimode transceivers also consume less power than singlemode transceivers. In a large data centre with thousands of links, a multimode fibre cabling solution can provide substantial cost savings from both fibre transceiver and power/cooling perspective

Which One to Choose?

When selecting singlemode fibre or multimode fibre, the most important thing to consider is the distance requirement.

Within a data centre, it's typical to use multimode fibres which can get you 300-400 meters. If you have very long runs or are connecting over longer distance, singlemode fibre can get you 10km, 40km,

80km, and even farther. You just need to use the appropriate optics for the distance required, and again, the prices go up accordingly.



Commonly, singlemode fibre gives a higher transmission rate and up to 50 times more distance than multimode fibre, but it also costs more.

Also note that the singlemode fibre and multimode fibre are not compatible. You cannot mix multimode and singlemode fibre between two endpoints. The optics are not compatible either.

The below table outlines the international standards organisation classification for singlemode and multimode fibre which describe the strength for speed and distance.

Transmission speed:	1 Gb/s	10 Gb/s	40 & 100 Gb/s
OM1 – 62.5/125µm	275/550m (850/1300nm)	33m	
OM2 – 50/125µm	550/550m (850/1300nm)	82m	
OM3 – 50/125µm	800/550m (850/1300nm)	300m (850nm)	100m (850nm)
OM4 – 50/125µm	1100/550m (850/1300nm)	550m (850nm)	125m (850nm)
Single Mode OS1/OS2 – 9/125µm	5000m (1310nm)	10000m (1310nm)	10km/40km (1310/1550nm)

From the above table, we can see that OM1 is the 62.5-micron fibre, OM2/OM3/OM4 are the 50-micron multimode fibres, while the singlemode is the 9-micron fibre.

OM1 multimode fibre was used to be the most common multimode fibres in the 80's and 90's. However, it is generated accepted that OM1 will soon be obsolete for the lowest data carrying capacity and shortest distance limitations as compared with other multimode fibres. As for the 50-micron multimode fibres, they are the most commonly used fibre types today, especially the OM3 and OM4 cables. In terms of the performance in 50-micron and 62.5-micron multimode fibres, the difference lies in the fibre's bandwidth, or the signal-carrying capacity. Bandwidth is actually specified as a bandwidth-distance product with units of MHz-km that depends on the data rate. As the data rate goes up (MHz), the distance that rate can be transmitted (km) goes down. Thus, a higher fibre bandwidth can enable you to transmit at higher data rates or for longer distances. For example, 50-micron multimode fibre offers nearly three times more bandwidth (500 MHz-km) than FDDI-grade 62.5-micron fibre (160 MHz-km) at 850 nm.

With the emerging demand for 40G and 100G network, we are seeing more customers install SMF (lower loss and higher bandwidth) and using them even in shorter distance connections because SMF allows for single pair upgrade to 40G, 100G and possible 400G in the future. Therefore, these customers will not need to retrofit their fibre infrastructure to migrate to future high-speed technologies.

Below is a quick comparison to compare the two modes:

Parameter	Singlemode	Multimode
Fibre Cost	Low	High
System Cost	High	Low
Loss	Low	High
Bandwidth	High	Low
Distance	Up to 60km	Up to 2km
Transmission Speed	Supports Up to 40G (Single-pair)	Supports Up to 400G (Single-pair)

Conclusion

Both singlemode and multimode optical fibres have their own features. Singlemode fibre cabling system is suitable for long-reach data transmission applications i.e. best used for distances exceeding 550 meters and widely deployed in carrier networks, MANs and PONs. Generally, multimode fibre is more cost-effective choice for data centre applications up to 550 meters. Multimode fibre cabling system has a shorter reach and is widely deployed in enterprise data centres and LANs.

Besides the transmission distance, the overall cost should also be taken into consideration. No matter singlemode system or multimode system, you should choose the one that best suits your network demands.

This white paper has given you some ideas about why singlemode fibre outperforms multimode fibre in terms of achievable link lengths and why singlemode optical fibres are more expensive. It also states the advantage of MMF is cheaper than SMF, and multimode connectors are cheaper and easier to terminate reliably in the field. Whether to use singlemode or multimode depends on the application and budget constraints.

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