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MULTIMODE OR SINGLE-MODE OPTICAL FIBER?

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Summary

Cloud computing and web services continue to drive increased bandwidth demand, pushing data communications rates from 10Gb/s to 400Gb/s and beyond in enterprise and data center networks.

These higher speeds might lead system designers to believe that singlemode fiber enjoys an increasing advantage over multimode fiber in premises applications. However, higher Ethernet speeds do not automatically mean that singlemode fiber is the right choice.

Although singlemode fiber holds advantages in terms of bandwidth and reach for longer distances, multimode fiber easily supports most distances required for enterprise and data center networks, at a cost significantly less than singlemode.

Multimode and Single-Mode. What is the difference?

The two fiber types are named by the way they transmit light. Singlemode fibers have a very small core (< 10 µm diameter) that permits only one mode or ray of light to be transmitted and are generally designed for systems of moderate to long distance (e.g., metro, access and long-haul networks). This small core requires precise alignment to launch light from the transceiver laser into the core, driving up the optical component costs. The small core also means that end face contamination of a singlemode connector is much more harmful. A small particle can cause a failure in a singlemode link, but not affect the performance of a similar multimode link.

Multimode 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. Because multimode systems are designed for short reach applications, power requirements are lower than singlemode systems, a key advantage in data centers where power consumption is a critical issue. Similarly, multimode connectors cost less than single-mode connectors because of the more stringent singlemode alignment requirements. 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 greater installation flexibility.

For these reasons, multimode fiber systems continue to be the most cost-effective choice for enterprise and data center applications up to the 100-150 meter range. Between 150 and 500 meters, the desired application speed and future migration plans need to be considered, while links beyond 550 meters generally require singlemode fiber.

Beyond the reach of multimode fibers, it becomes necessary to use single-mode fiber. When assessing single-mode fibers, be sure to consider newer options. A bend-insensitive, full-spectrum single-mode fiber provides more transceiver options, greater bandwidth and is less sensitive to handling of the cables and patch cords than is conventional single-mode fiber.

Which Multimode Fiber Type, and Why?

At one time, the network designer or end user who specified multimode fiber for short reach systems had to choose from two fiber types defined by their core size, namely, 50 micron (µm) or 62.5 µm. Now, that choice is slightly different: choose from OM3, OM4, or the newest OM5 grade of 50 µm multimode fibers. Today, 62.5 µm OM1 and 50 µm OM2 multimode fibers are virtually obsolete, and their use is relegated for use with extensions or repairs of legacy, low speed systems.

Today, 50 µm Vertical Cavity Surface Emitting Laser (VCSEL)-optimized multimode OM3, OM4, and OM5 fibers offer significant bandwidth and reach advantages for short reach applications, while preserving the low system cost advantages of multimode fiber. OM3 fiber offers the lowest initial cost, but the shortest link distance support. Generally limited to less than 100-meter link distances at speeds greater than 40Gb/s, it cannot support the longer reaches found in some of the larger enterprise data centers. OM4 fiber supports the common 100m link distance for today's 100 and 400 Gb/s applications, which remains the proposed reach for the latest

800Gb/s application under development. OM5 fiber supports the same link distance as OM4 fiber when used with 850nm based applications and has the added capability of extending the reach for multimode WDM applications, including 100Gb/s BiDi, 100Gb/s SWDM4, and 400GBASE-SR4.2, making it the most future-proof solution.

In the Enterprise

In enterprise Local Area Networks (LANs), OFS' LaserWave® family of multimode optical fibers can easily support reaches up to 550 meters for the 10 Gb/s speeds typically used today. Looking at higher speed 100 and 400 Gb/s data rates, OFS' LaserWave multimode fibers can support reaches up to 100 or even 150 meters.

In the Data Center

For the increasingly diverse needs of today's wide variety of data centers, LaserWave FLEX 550 (OM4) and LaserWave WideBand (OM5) fibers support the typical 100 - 150 meter maximum distances seen in all but the largest mega data centers. Even the largest warehouse-scale data centers contain many thousands of shorter server-to-server, server-to-top-of-rack or end-of-row connections that benefit from multimode fiber's link cost advantage.

As data rates increase, LaserWave WideBand (OM5) fiber is designed for use with multimode Wavelength Division Multiplexing (WDM) technology that uses multiple lanes (wavelengths) to transmit signals over a single fiber, increasing the bandwidth by up to factor of four. There are two different multimode WDM solutions currently on the market. Short Wavelength Division Multiplexing (SWDM4) modules send traffic in one direction over four wavelengths in a fiber, so a duplex (2-fiber) link, for example, has a transmit fiber and a receive fiber. In contrast, Bi-directional (BiDi) modules transmit and receive signals travel on the same fiber bi-directionally, using two different wavelengths. Both these WDM technologies minimize the number of fibers required to achieve higher speeds and preserves the economic benefit of using multimode.

OFS' LaserWave WideBand (OM5) multimode fiber supports longer link distances than OM4 fiber when deployed in WDM applications. Current multimode WDM products include 100 Gb/s BiDi and SWDM4 transceivers that support duplex 150-meter 100Gb/s links, exceeding the 100-meter reach of OM4 fiber. 400GBASE-SR4.2 is the first IEEE 802.3 Ethernet standardized multi-wavelength VCSEL-MMF application, supporting 150-meter link distances for 4-pair 400Gb/s Ethernet. Completely backward compatible with OM4 fiber, LaserWave WideBand fiber can be installed now to support today's 10G speeds and be ready for tomorrow's 800G and even 1.6T WDM applications.

Total Cost

Multimode fiber continues to be the more cost-effective choice over singlemode fiber for short reach applications. While the actual cost of a multimode cable is greater than that of single-mode cable, it is the optics that drives the total cost of a link, overshadowing higher cable costs. Also, as optical links shorten, the fiber cost itself becomes less of a factor and the connectivity components make up more of the passive link cost.

On average, singlemode transceivers continue to cost from 1.5 to 4 - 5 times more than multimode transceivers, depending on data rate. As faster optoelectronic technology matures and volumes increase, prices come down for both, and the cost gap between multimode and single-mode decreases. However, singlemode optics have continued to be more expensive than their equivalent multimode counterparts.

Multimode transceivers also consume less power than singlemode transceivers, an important consideration especially when assessing the operating cost of powering and cooling a data center. In a large data center with thousands of links, a multimode solution can provide substantial cost savings in both capital and operations.

Installation and Operation

An important consideration for enterprise environments is multimode fiber's easier installation and field termination, making frequent moves, adds and changes easier.

Multimode fiber's larger core size makes it less susceptible to contamination. Because a singlemode fiber core is so much smaller than a multimode core, microscopic contaminants can cause high loss and system failure in a singlemode link, while having minimal effect on a multimode system.

Planning for the Future

Industry standards groups including IEEE 802.3 (Ethernet), INCITS T11 (Fibre Channel), TIA, ISO, IEC, and others continue to include multimode fiber as the short reach solution for next generation speeds. This reinforces multimode fiber's continued economic advantage for these applications.

IEEE includes multimode fiber in its 100G and 400G Ethernet standards as well as its pending 800G standard. TIA, ISO, and IEC have published new multimode fiber standards that include OM5 multimode fiber. This latest multimode fiber is designed to support multiple wavelengths using WDM technology, while maintaining OM4 backward compatibility. In this way, end users can obtain greater bandwidth and higher speeds from a single fiber by simply adding wavelengths. OFS' LaserWave® WideBand (OM5) multimode fiber supports the continued economic benefit of deploying short reach optics over multimode fiber – as opposed to more expensive single-mode optics.

Conclusion

In general, multimode fiber continues to be the most cost-effective choice for enterprise and data center applications up to the 100-150 meter range. For lower speed 10Gb/s solutions, 550 meter link distances can be supported. Beyond that, singlemode fiber is necessary.

For multimode fiber, 50 µm should be used, specifically the higher bandwidth OM4 or wide band OM5 grades. OFS' family of LaserWave Multimode Optical Fibers offers the full performance range and have better optical and geometry specifications than required by the standards. This can allow for reduced connection / insertion loss and greater systems margin, which in turn enables longer reach, additional connections, and greater systems reliability.

If the network's transmission distances dictate the use of singlemode fiber, consider specifying bend-insensitive, zero water peak (ZWP), full spectrum fibers, such as the OFS family of AllWave® fibers. Depending on the application, these fibers offer various options for bend performance, attenuation and spliceability.